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NEW BRUNSWICK SUBSURFACE DRAINAGE PROJECT: A STUDY OF WATER QUALITY EFFECTS OF INTENSIVE AGRICULTURAL PRODUCTION

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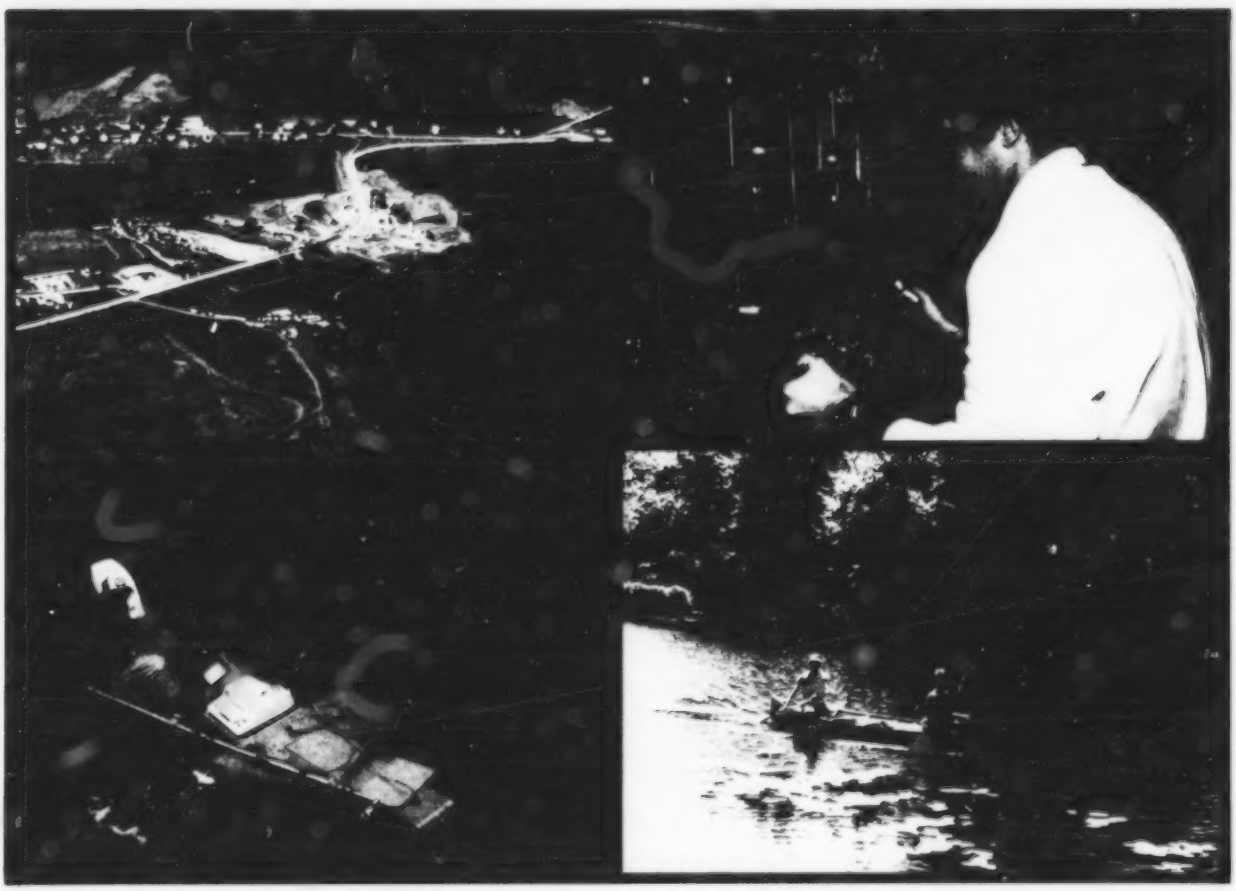

Canada

INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER QUALITY BRANCH
MONCTON, NEW BRUNSWICK

NEW BRUNSWICK SUBSURFACE DRAINAGE PROJECT: A STUDY OF WATER QUALITY EFFECTS OF INTENSIVE AGRICULTURAL PRODUCTION

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EXECUTIVE SUMMARY

New Brunswick farmers in the Upper Saint John River Valley cultivate approximately 20,000 ha of seed, processing and table potatoes annually. The soils of the region are characteristically coarse-textured, and low in organic matter and water holding capacity. The application of medium to high rates of agro-chemicals to these soils, combined with a generally humid, short-season climate could produce leaching losses and undesirable water quality impacts.

Monitored agricultural subsurface drainage provides an effective means of determining the movement of agricultural chemicals from the soil surface, to the root zone, and eventually to ground water. Experimental farm studies have shown that hydrologic responses and mass losses observed in subsurface drainage studies are directly analogous to results from larger scale ground water studies.

The work undertaken by Agriculture Canada, the New Brunswick Department of Agriculture and Environment Canada has produced the first subsurface drainage water quality data unique to New Brunswick.

The herbicides dinoseb and metribuzin were both detected in the season they were applied and both carried over to the following growing season. Changes in major ion chemistry (e.g. - elevated nitrates) were also noted as a result of fertilizer application. Thus movement of nutrients and pesticides from the root zone has been observed on a field scale with obvious implications to ground water.

Future work in this area should:

1) provide scientific support to concurrent IWD pesticide and aquifer studies.

2) investigate ecosystem response to tile drainage effluent and surface runoff on a field scale.

3) be assessed for input into the pesticide re-evaluation process.

4) maintain the level of cooperation between Agriculture Canada, the provincial departments of agriculture and Environment Canada so that the relationship of sustainable agriculture and sustainable development may be fully explored by focussing upon determining agricultural management practices that do not degrade water resources.

ABSTRACT

This report presents the observations obtained by Environment Canada, Inland Waters Directorate, Water Quality Branch, Atlantic Region for the New Brunswick Subsurface Drainage Project, a joint study with Agriculture Canada and the New Brunswick Department of Agriculture. Water Quality Branch activities centred upon the investigation of pesticides in tile drainage effluent while the agricultural researchers were primarily interested in nutrient export.

In 1987 the in-use pesticide dinoseb was observed in tile effluent from three potato fields having recent dinoseb histories indicating carry over from the previous growing season. Concentrations ranged from 1.1 µg/L to 0.11 µg/L. Dinoseb was also reported in the 1987 post-application tile effluent with a highest single observation of 44.0 µg/L. Susbsequent samplings indicated diminishing dinoseb concentrations with time. Results from 1988 were similar though maximum concentrations were lower. Samples from one site indicated that dinoseb residues had remained in the soil matrix 18 months after the last known application. Major ion and nutrient data for tile effluent indicated shifts in calcium, alkalinity, potassium, nitrate, and total nitrogen concentrations as a result of fertilizer application.

Mass balance and transport calculations in 1987 indicated that the in-season sampling carried out by the Water Quality Branch accounted for 0.001% of the dinoseb that was applied to two study fields.

In 1988 the triazine herbicide metribuzin was detected at concentrations ranging from 1.53 μg/L to 0.06 μg/L. The first observation (1.53 μg/L) occurred 2 months after metribuzin had been applied. Four samples from the spring of 1989 contained metribuzin at concentrations ranging from 0.143 μg/L to 0.305 μg/L thus indicating carry over from the previous season.

SOMMAIRE

Ce rapport présente les observations faites par la Direction de la qualité des eaux, région de l'Atlantique, au cours du "Projet de drainage souterrain, Nouveau-Brunswick"; une étude effectuée conjointement avec Agriculture Canada et le Département de l'agriculture du Nouveau-Brunswick. Les investigations effectuées par la Direction de la qualité des eaux on portées sur les pesticides dans les effluents de drainage souterrain, tandis que les chercheurs d'Agriculture Canada se sont surtout intéressés au movement et à la perte des éléments nutritifs.

Le pesticide en usage dinosèbe a été décelé en 1987 dans les effluents de trois champs de patates ayant subit par le passé des applications de dinosèbe, indiquant ainsi un rapport de la saison précédente. Les concentrations détectées variaient de 1,1 µg/L à 0,11 µg/L. Suite à son application de 1987, le dinosèbe a été détecté dans les effluents, la plus forte concentration étant de 44,0 µg/L. Des résultats similaires ont été obtenus en 1988, mais les concentrations maximales détectées étaient moins élevées. L'analyse d'échantillons provenant d'un des sites a démontré que des quantités résiduelles de dinosèbe sont restées dans le sol 18 mois après la dernière application connue du pesticide. Les données sur les ions majeurs et sur les éléments nutritifs ont démontré des changements dans les concentrations de calcium, d'alcalinité, de potassion, de nitrate et d'azote total, suite à l'application d'engrais.

Il fut estimé en 1987, par calculs de balance et de transport de masse, que l'échantillonnage effectué en saison par la Direction de la qualité des eaux a rendu compte de 0,001% du dinosèbe total appliqué sur deux des champs étudiés.

En 1988, la métribuzine, un herbicide de la famille des triazines, a été décelée à des concentrations variant de 1,53 µg/L à 0,06 µg/L. La première observation (1,53 µg/L) est survenue deux mois après l'application de métribuzine. Quatre échantillons prélevés durant le printemps de 1989 contenaient de la métribuzine à des concentrations variant de 0,143 µg/L à 0,305 µg/L, indiquant ainsi un rapport de la saison précédente.

INTRODUCTION

There are two principal environmental impacts that have been traditionally associated with agriculture: the first is elevated levels of nutrients in surface waters draining agricultural fields, and the second is chemical contamination due to pesticide usage (Maine Soil and Water Conservation Commission, 1977). Lee and Nielsen (1987) have expressed concern that up to 53.8 million people in the United States could be affected by agricultural chemical contamination of groundwater by either nitrates and/or pesticides. Concern for surface water quality has led the Water Quality Branch to undertake toxic chemical surveys centering on regional in-use agricultural pesticides (Clair and Bailey, 1986; Clair et al. 1987; O'Neill and Bailey, 1987).

Pesticides may reach both ground and surface waters by several pathways, including: surface runoff, erosion, leaching, spray drift, improper disposal of containers, and accidental spills. There have been reported cases of fish kills in the State of Maine as a result of: guthion being washed off a field with a heavy rain (runoff), premerge weed killer observed in Everett Brook due to a leaky valve at the mixing site (accidental), and guthion container leachate in Whitney Brook (improper disposal). In an instance where pesticide containers were crushed and buried in 1975, it was found that in 1977, endosulphan, dinoseb, and guthion were leaching into ground water from the disposal site (Maine Soil and Water Conservation Commission, 1977).

After an applied pesticide reaches the soil matrix it may be affected by various chemical, biological and physical processes. It may undergo photo-decomposition, degradation and metabolization by plant and bacteria, volatilization and runoff from the surface or absorption, chemical decomposition, biological degradation, capillary flow and leaching from the

unsaturated layer of soil (Gillis and Walker, 1986). When pesticides reach the saturated zone, they may be transported via the processes of advection and dispersion, may undergo adsorption, partitioning ion exchange, or may undergo chemical or biological transformation to substances that may be more or less hazardous than the parent compound (MacKay et al., 1985). The principal reactions that occur in the saturated zone are hydrolysis and oxidation. Biotransformation can take place with the rate dependant upon pH, temperature, number and types of species of organisms, the concentration of the substance and the presence of microbial toxicants and nutrients (MacKay et al., 1985).

Recent evidence indicates that pesticides are being observed in ground water as a result of agricultural practices. Gillis and Walker (1986) cited the triazine herbicide, atrazine, and the dinitrophenol herbicide, dinoseb as having been observed in ground water in North America. Both have been observed in New Brunswick and Prince Edward Island and for this reason have been placed on the Inland Waters Directorate Water Planning and Management Branch priority list, (Gillis and Walker, 1986).

Clair and Bailey (1986); Clair et al. (1987) and O'Neill and Bailey (1987) concluded that dilution by receiving streams made the detection and quantitation of in-use pesticides in surface waters difficult even though pesticide use was suspected or known in a basin. To better determine the direct inputs from agriculture, the monitoring of a small first order stream or point source was indicated. For this reason, the Water Quality Branch, Atlantic Region at the invitation of Agriculture Canada, and the New Brunswick Department of Agriculture, undertook a study of water quality effects associated with subsurface drainage systems. The study afforded the opportunity to investigate the fate of in-use pesticides on tile drained potato fields where drainage flow,

precipitation amounts, and application rates of pesticides were known, while providing a point source for sample collection.

Hill (1976) defined agricultural land drainage as the removal of excess water from soil by various means in order to make the drained land more suitable for agricultural purposes. Drainage can be accomplished by use of ditches, drainage canals and channeling natural water courses. The type of land drainage encountered in this study was subsurface tile drainage which is a more delicate control form than the aforementioned methods.

The advantages of subsurface drainage to farmers in the Atlantic region are numerous. They include: earlier drying and warming of soil in the spring, removal of excess water from the root zone thus allowing a continuous supply of oxygen, deeper root penetration, better soil structure with less compaction, a decrease in surface runoff and erosion, less winter soil heaving, increased productivity and a wider range of crop choices (ACAE, 1986). Malecki and Sullivan (1987) reported that land drainage has a direct effect on the farm economy by improving crop yields and areas under cultivation, while at the same time cautioning as to impacts upon natural wetlands. Milburn and Gartley (1987) reported that in a New Brunswick farmer survey, 59% of respondants felt that subsurface drainage had "greatly improved" production efficiency.

Of primary interest to the Water Quality Branch is the effect of Agricultural management practices upon the transport of agricultural chemicals and pesticides from an application site to any receiving aquatic environment. Tile drainage effluent provides an indicator of the quality of water that is entering the surface water system as well as leaving the root zone and entering ground water. The concentrations of

pesticides found in tile effluents are similar to those in the ground water, thus providing an inference about pesticide behavior in the ground water environment (Hallberg et al., 1986). Additionally, water quantity, as determined by a V-notch weir or H-flume, coupled with water chemistr monitoring can be used to calculate mass losses. With roughly 50,000 ha of agricultural land utilized for potato production, in Northwestern New Brunswick, this study afforded the opportunity to gauge the impact of water movement into the unsaturated zone and eventually the water table. It was intended that this field study would provide a means to investigate the potential impacts of agricultural pesticides on both ground water and surface water in Atlantic Canada.

METHODOLOGY

Project Scope

The subsurface drainage project was a federal-provincial effort initiated by Agriculture Canada and the New Brunswick Department of Agriculture to investigate the loss of nutrients from potato fields. Funding to undertake a major part of this work was provided through the Technology Initiative of the Canada-New Brunswick Agricultural Food Development Subsidiary Agreement (1984-1989). In order to accurately calculate nutrient export from the fields, flumes were installed by Agriculture Canada and the New Brunswick Department of Agriculture (NBDA) to monitor and record tile flow from each study field.

The Water Quality Branch of Environment Canada was invited to participate in the project with a specific role to investigate in-use pesticides and their presence in tile drainage effluent. Branch activities entailed close cooperation with the provincial and federal departments of Agriculture, and frequent contact with lay contract collectors. The Water Quality Branch used the services of NBDA lay collectors to sample the study fields on a predetermined schedule. Branch staff also sampled the fields in the spring of 1987, 1988 and 1989 and during the growing season. The Water Quality Branch, Analytical Services Division, performed the chemical analyses of water samples for the pesticides of interest and also conducted major ion and nutrient analyses to characterize the effluent and to provide a quality assurance function with Agriculture Canada.

Site Descriptions

Five suitable farm fields in Northwestern New Brunswick were selected by Agriculture Canada, and NBDA for the purposes of the study. Criteria for selection were based upon the accuracy and extent of records of pesticide use and crop rotation, past pesticide and fertilizer usage, size of the tile drained field and projected field usage. Four sites were in the Grand Falls area while the fifth was near Florenceville. Figure 1 illustrates the general study location while figures 2 through 6 illustrate each study site. Table 1 gives the NAQUADAT station number and description of each of the five study sites. Each field was identified by a letter, and will be cited by the designations "B, O, P, R, and S".

The study sites consisted of tile drained areas ranging from 3.0 hectares to 10.4 hectares. The soil on all the study fields are typically sandy loam of low organic content. Table 2 presents the soil characteristics of the study sites. The tile was perforated PVC agricultural drainage tubing that was systematically installed at a depth of approximately 1 metre using either a drainage tile trencher or a trenchless drainage plow, and graded for gravitational flow.

Two site outlets, R and P, were 75 metres from intermittent streams, and two, B and O, drained into low areas only. The last site, S, Figure 5, was the most interesting in that a small pond at the outlet supported biological activity making it suitable for population studies. The outlet at site S was observed to have continuous flow throughout the study period indicating that the tile system was subject to ground water inputs. Located about 25 metres south-west of the outlet was a second dugout pond that had been used as a disposal site for pesticide containers. Fifteen containers could clearly be seen under heavy aquatic growth. Along the

southwesterly border of the field were found in excess of 20 discarded dinoseb containers that had been disposed of on the elevated rock border between the fields. These containers had clearly been punctured, indicating more recent triple-rinse and puncture disposal practices. These discoveries while reconnoitering the site provided additional impetus for the dinoseb aspect of the study that was to follow.

The New Brunswick Department of Agriculture conducted interviews of the co-operating farmers to determine past and proposed crop and pesticide usage. The 1982 to 1986 crop production histories, with the types and frequencies of pesticide applications and the 1987 and 1988 crop production plans with tentative pesticide application schedules were obtained. Table 3 summarizes the anticipated 1987 crop production plans and the pesticide application frequency as derived from 1986 growing season information.

Parameter Selection

The 1987 Water Quality Branch sampling protocols were formulated from the documented 1986 pesticide application data and from the anticipated 1987 crop production plans. Enough flexibility was allowed so that target chemicals could be modified to suit actual in-use patterns. Sampling in 1988 was dependent upon both the 1987 applications and crop plans for 1988. This necessitated a dynamic, yet focussed, parameter list as opposed to a set list for the study. A review of the analytical methodologies indicated that there were existing methods for six of the pesticides used during 1986. These included dinoseb, metribuzin, MCPA, chlorothalonil, fenvalerate, and deltamethrin. The six pesticides were priorized so that analytical resources could be effectively allocated (O'Neill et al., 1988). Dinoseb, metribuzin and chlorothalonil were identified as the pesticides of principal interest. The available analytical resources were

concentrated on a minimum number of fields to generate the greatest amount of data.

The three remaining pesticides on the initial list, MCPA, deltamethrin and fenvalerate, were assigned lower priority due to the rapid breakdown of the pyrethroids, and the fact that MCPA is primarily used on grain. The pesticides of interest, their chemical and trade names and the NAQUADAT parameter codes are listed in Table 4.

Major ion and nutrient parameters, Table 5, were included in the analytical protocol to describe and characterize the tile effluent, and to provide a quality assurance function for Agriculture Canada. Extensive sampling by Agriculture Canada to calculate the nitrate removed by the tile drainage systems, and to indicate what water quality changes might occur in tile effluent and ground water after the application of fertilizers.

Sampling

Sample collection of the tile drainage outlets was carried out by contract collectors hired by NBDA, through the Canada/New Brunswick Agricultural Food Development Subsidiary Agreement. Sampling was augmented by personnel from the Water Quality Branch. Water Quality Branch staff collected a set of springtime samples and reconnoitered the sites in April 1987. Post rain event collection was the responsibility of the contract collectors with supplemental collection by the Water Quality Branch. It was anticipated that the springtime samples would yield background information and point out any carry over from previous growing seasons; pre-application rain events would yield background concentrations under normal growing conditions; and post-application collection would elucidate any pesticide export in the tile drainage effluent. An end of season sample collection would indicate the duration

of pesticide observations and be useful for comparison with sample collection the following spring. Historical monthly precipitation observations from 1982 to 1986, Table 6, indicated that ample precipitation could be expected in the Grand Falls area.

All samples collected throughout the study, were shipped on a next day basis to the Water Quality Branch laboratory. Coolers and freezer packs were used both in the field during collection and during shipping in order to keep the samples as cool as possible. Upon arrival in Moncton the samples were placed in storage refrigerators and initialized on the laboratory management system.

Analytical Procedures

All major ion and nutrient analyses were carried out following the Water Quality Branch "Analytical Methods Manual 1979" (Environment Canada, 1979). Dinoseb was determined by using *in situ* acetylation with acetic anhydride, extraction with petroleum ether (Stokker, 1986), and quantified on capilliary column gas chromatography (CCGC) with electron capture detection. Metribuzin was determined using an XAD-resin column to extract the target compound followed by elution with ethyl acetate and quantification on packed column gas chromatography, with nitrogen-phosphorus detection. This was subsequently changed in mid 1987 to capillary chromatography with a resultant lowering of the detection limit. Chlorothalonil was extracted with hexane, and quantified by CCGC with electron capture detection. The extraction methodology for the pyrethroids was obtained from Environmental Protection (Julien *et al.*, 1985) with in-house modification of columns and chromatographic conditions to match Water Quality Branch instrumentation. MCPA was quantified using the BF_3/methanol derivitization method for

phenoxy acid herbicides as per the Analytical Methods Manual 1979 (Environment Canada, 1979).

Early in the sampling season, it became apparent that special bottle identification of tile drainage samples was required by the laboratory. The concentrations of nitrate and total nitrogen exceeded the routine operational range of the analytical techniques, resulting in the need to dilute the samples prior to analysis. Nitrate concentrations were especially troublesome when quantifying sulphate by ion chromatography, due to nitrate masking (V. Komadina, personal communication).

Quality Assurance/Quality Control

To ensure the validity of observations, a quality assurance/quality control aspect of the project was implemented. This quality control program consisted firstly of Water Quality Branch staff instructing the contract collectors in appropriate sampling , numbering and shipping procedures. The inclusion of random duplicates and triplicates was also used to verify sample collection and quantification. Spiked pesticide samples were incorporated to verify recoveries from the sample matrix. As part of routine in-laboratory quality control, laboratory spikes and method blanks were included by laboratory personnel to check laboratory extraction performance. All positive pesticide observations were verified on at least one additional column of different polarity. And if observations were sufficiently high, every attempt was made to obtain a gas-chromatograph/ mass spectrometer confirmation from an outside institution.

Additionally, the Water Quality Branch Analytical Services Division participates in several quality control programs and audits of an intra-laboratory and inter-laboratory nature for the determination of pesticides,

major ions, metals and nutrients (Brun, 1986; Brun, 1987). This continual monitoring of analytical performance ensures the accuracy, precision, and validity of data.

Nitrate observations reported by the Branch could also be used for an inter-laboratory comparison with Agriculture Canada to ensure comparability between laboratories.

RESULTS AND DISCUSSION

Early in 1988 an interim report (O'Neill et al., 1988) was prepared to describe the work completed during 1987, the first year of the study. Discussion focussed upon major ion, nutrient and pesticide presence in the tile effluent. Observations spanning both the 1987 and 1988 growing seasons will be presented in this report on a site by site basis.

Though recorded meteorological data (Table 6) indicated that there should have been several rain events to trigger tile flow, this was not the case. Yet, April to November precipitation was within 4% of normal. Thus, only a limited number of samples were collected during June, July and early August.

The realities of field scale operations were also apparent each year as farmers would modify pesticide applications at the last moment. The 1986 pesticide application data was useful as a planning tool to formulate background sampling but most of the 1987 and 1988 sample collection had to be carried out on an ad hoc basis. Fortunately the flexibility of the Water Quality Branch laboratory eased this aspect of project management.

Tables 7 through 11 present chronologically the observations recorded during the April 1987 to April 1989 period of study for each field.

Site B

Site B had a monitored subdrained area of 3.1 hectares. In 1986, this field was in red clover and did not receive any fertilizer or pesticide applications. Metribuzin was last used at this site in May of 1984 as a pre-emergent herbicide. In 1987 the site was in timothy/clover hay and received only

2.5 T/ha lime on October 30, 1987. The projected crop for 1988 was process/table potatoes. This site provided an opportunity to observe the water quality effects as a result of a change from three years of clover/wheat to intensive potato production.

In 1987 this site displayed nitrate concentrations, which at the start of the growing season were 3-4 mg/L, an order of magnitude below the other sites, and diminished to less than 1.0 mg/L by November 5th. Alkalinity was greater than calcium, typical for ground waters in New Brunswick while other anions and cations were lower than the sites in active potato production. Historically this site had been in potato production 1 out of the 6 previous years, a fact reflected by the nitrate observations. As there was no history of dinoseb use at this location, and this site had been chemical free in 1986, it was used as a control site in 1987 for both dinoseb and metribuzin.

Two samples from the April collection and four samples from May 7, 1987 indicated metribuzin presence at concentrations ranging from detection limit (0.01 μg/L) to twice detection. An improvement in detection limit was noted in the samples of November 1987. Again all samples were reported ranging from detection limit (0.001 μg/L) to three times detection limit. It would appear that there were either residuals present in the soils of site B (from 1984) or more likely, as detection limit observations were reported at two detection limits an order of magnitude apart, a co-extractive may have been interfering. All of the dinoseb samples collected during 1987 were less than the detection limit of 0.02 μg/L at this site.

In 1988 the use of the field was significantly different from the three previous growing seasons in that the field was cropped with processing/table potatoes and on May 11th, and on

May 14th respectively, muriated potassium and fertilizer (15-15-15 banded) were applied. On May 30, 1988 0.75 kg/ha of metribuzin (Lexone DF) was applied as a pre-emergent herbicide.

On May 1, 1988, three metribuzin samples were reported as less than detection limit while a fourth was slightly greater than detection limit. No samples were collected until August 8, 1988, due to the absence of tile flow. However, metribuzin was detected in all twenty samples collected between August 8th and November 9th. The maximum observation was 1.53 µg/L on August 8th over 2 months post-application. By the 9th November, the last samples of 1988, the concentrations had diminished to 0.39 and 0.24 µg/L.

Duplicate water samples collected on April 11 and 12, 1989 indicated metribuzin concentrations ranging from 0.305 µg/L to 0.143 µg/L. These observations are within the range of observations reported in the fall of 1988, were observed eleven months post application, and are indicative of carry over from the 1988 growing season. These concentrations were quantitatively confirmed by the Water Quality Branch laboratory using gas chromatography with mass selective detection.

All ten dinoseb samples collected in 1988 were reported as less than the detection limit of 0.02 µg/L which is consistent with the 1987 data and the field history.

Major ion and nutrient samples clearly illustrate direct changes in water quality as a result of fertilizer applications. The 19 samples collected up until May 1, 1988 indicate calcium concentrations lower than alkalinity, and nitrate no higher than 3.8 mg/L. However, samples collected from August 8, 1988 onward indicate calcium being greater than alkalinity and significant increases in magnesium, potassium,

chloride, sulfate and nitrate. Specific conductance also dramatically changed from 104 µS/cm on May 1, 1988 to 459 µS/cm on August 8, 1988. There were also fluctuations in the nutrient concentrations post-harvest (Oct. 14th) which are not uncommon due to reduced uptake, plant release, and soil disturbance.

The changes in water quality were the most dramatic at this site; due to the major shift in agricultural activity from 1986 to 1987 and 1988.

Site O

Site O was over three times larger than site B with 10.4 ha of monitored subdrained field. In 1986 the field had been in barley and had received two fertilizer applications and one application of MCPA (4 chloro - 2 methyl phenoxyacetic acid). The 1987 crop was process and table potatoes. Fertilizer was applied on May 2, 1987 and paraquat was used as a pre-emergent herbicide. The fungicide mancozeb was used frequently during 1987, while no insecticides were used.

In 1987, site O was observed to have the second highest seasonal mean nitrate concentration of 22.5 mg/L. The samples from the 7th and 8th of April 1987 are markedly lower for nitrate than are those from the 17th of June. The four samples from the 17th of June are also lower in major ion content that the remainder of the 1987 samples that followed. Twelve samples collected on June 28, 29 and 30th 1987 had the highest calcium, chloride and nitrate values recorded at the site. Concentrations diminished through to the end of the season such that by late March 1988 levels similar to April 1987 were observed.

In 1988 the crop was changed to field peas with planting and fertilizer application on June 15, 1988. As with the

previous year, a change in the major ions was observed in samples collected after fertilizer application.

Metribuzin and dinoseb analysis were carried out in 1987 even though this site did not have a recent history of either. Two metribuzin observations, one at the detection limit of 0.01 µg/L, and one at twice detection limit, were reported in 1987. These are felt to be due to coextractives and are similar to observations from site B where detection limit observations were observed in 1987. Twelve other metribuzin samples in 1987 were all less than the detection limit. Dinoseb concentrations from 1987 were all less than detection limit except for one observation at the detection limit of 0.02 µg/L. Of eight samples collected on September 14 and 15, 1987, 3 indicated chlorothalonil concentrations ranging from 2 to 3 times the detection limit. These observations are suspect as they were interspersed with values less than the detection limit of 0.002 µg/L and there was no indication of chlorothalonil use.

In 1988 only dinoseb was quantified at this site, as dinoseb is registered for use as a pre-emergent herbicide in pea production. All samples prior to July 4, 1988 were less than detection limit while eight observations from July and October indicated dinoseb concentrations ranging from 0.05 to 0.45 µg/L. Though dinoseb was not cited on the 1988 crop history, the data indicate that it was present. Duplicate samples collected on April 11 and 12, 1989 indicated dinoseb concentrations of 0.03 µg/L to 0.08 µg/L. On other sites where dinoseb was used, samples collected the following spring always indicated dinoseb presence. Where dinoseb was reported in the spring of 1989, it confirms the observations recorded the previous fall and indicates that dinoseb was present. This is contrary to the farmers' records and is the only such discrepancy reported during the study. A possible explanation

is that dinoseb had been used elsewhere and was present in the sprayer used to apply the herbicide to this field.

Site P

Site P had 3.0 ha subdrained and had been in potato production in 1985 and 1986. In 1987 the site was in fallow and did not receive any chemical or fertilizer applications. The 1988 crop was again seed potatoes.

Even though this site did not receive any fertilizer in 1987, nitrate observations from the 22nd of September 1987 indicated significant concentrations. The residual nitrate observations during a year of fallow were a reflection of the previous intensive potato production at this site. Only six samples were collected in 1987 as Site B was being used as a control site.

Two samples collected on April 7 and 8, 1987 indicated dinoseb concentrations of 1.1 and 0.83 μg/L respectively. These observations indicated carry over from the previous (1986) growing season when dinoseb had been used twice, in the spring as a pre-emergent herbicide and in the late summer as a potato vine dessicant. Similar cross season carry over was also observed at two other sites. The elapsed time from the most recent application was 7 months. Samples collected on September 22, 1987 again indicated dinoseb presence at concentrations ranging from 0.14 to 0.23 μg/L, 13 months post application.

In the spring of 1988, single samples collected on March 28, 29, 31 and April 1, 2, 3 all indicated dinoseb concentrations ranging from 0.07 μg/L to 0.12 μg/L, 18 months post application. Four samples collected on May 1 and 2, 1988 did not indicate reportable dinoseb concentrations. On May 25, 1988 fertilizer was applied, and on June 7 dinoseb was

applied at a rate of 5.6 L/ha (Dytop) as a pre-emergent. Six samples collected on July 4 and 5 had dinoseb concentrations ranging from 1.3 to 0.06 µg/L.

Dinoseb was again applied as a vine dessicant on August 18, 24 and 31 at 5.6 L/ha (Dytop). Two samples collected on September 5, 1988 indicated dinoseb concentrations of 1.15 and 3.10 µg/L. Samples collected during October had concentrations ranging from 1.2 to 0.02 µg/L.

A set of triplicate samples collected on April 11 and 12, 1989 indicated mean dinoseb concentrations of 4.8 µg/L and 1.1 µg/L respectively. The observations of April 11 are the highest seasonal carry overs reported during the study period, and are a reflection of the 3 applications during August 1988.

This particular site clearly illustrated that there was not only measurable dinoseb carry over of 18 months in the soil matrix but that dinoseb also could move rapidly through 1 metre of soil to the tile system.

Site R

The tile drained field at Site R was 7.7 ha in area and was terraced in order to minimize the effects of surface erosion. This site had been in seed potatoes in 1986 and had received an application of dinoseb in May 1987 as a pre-emergent herbicide. The 1987 crop was seed potatoes, while in 1988 the crop was oats and barley. This site had the highest nitrate concentrations of any of the study sites even during the spring of 1987 and 1988. Observations for nitrate from March, April and May 1988 were higher than at any other site including those that had been in potatoes the previous season.

Dinoseb was detected in two samples from April 7 and 8, 1987 at concentrations of 0.11 and 0.14 µg/L. This indicates an eleven month carry over from the last known application in May of 1986. Four samples collected on June 28, 1987 during low tile output did not indicate measurable dinoseb concentrations. Dinoseb was used as a vine dessicant on September 4, 1987 at an application rate of 11 L/ha (Dytop). A single sample collected on September 14 indicated a dinoseb concentration of 44 µg/L in the tile effluent. This observation was reported during a period of very low tile flow. Eight samples obtained on September 22nd and 23rd contained between 2.0 and 1.4 µg/L dinoseb and sixteen observations between October 4th and 6th were at concentrations ranging from 0.43 to 1.00 µg/L on the 4th to 0.17 to 0.20 µg/L on the 6th.

The highest concentration of 44 µg/L and 5 subsequent samples were confirmed, qualitatively, by gas chromatography mass spectrometry at the National Water Quality Laboratory at CCIW in Burlington, Ontario (Forbes, personal communication, 1988).

Samples collected in March and April 1988, during the spring thaw indicated dinoseb concentrations ranging from 0.44 to 0.96 µg/L, 6 months post-application. Three samples in April and May did not indicate measurable dinoseb presence while 2 others did just above detection limit. Twelve samples collected during the month of October 1988 were also less than the detection limit of 0.02 µg/L. Duplicate dinoseb samples collected on April 11 and 12, 1989 were again less than the detection limit of 0.02 µg/L. This was roughly 18 months from the application of September 1987.

This site clearly indicated dinoseb carry over from one growing season to the following. Samples from the spring of 1987 and 1988 displayed this effect.

Site R had no history of metribuzin use and was used as a control site for metribuzin. Four samples in June of 1987 and four in May of 1988 were all reported as less than the detection limit at the time of analysis.

On June 4, 1988 MCPA was applied at a rate of 1.2 L/ha. Samples from the 4th of May, 4th and 5th of July 1988 and the 11th and 12th of April 1989 were all less than the detection limit.

Site S

Site S had a subdrained area of 7.3 ha and a history of intensive potato production (1982-1986). The 1987 crop was also potatoes. The tile outlet at this site recorded almost continuous baseline flow indicative of ground water input. A serious setback to the study occurred in 1987 at this site when the potato crop was diagnosed as being contaminated by a bacterial ring rot (BRR). This resulted in a field quarantine and curtailment of sample collection. The collection of all project samples from that point was carried out by NBDA employees knowledgeable in BRR management.

This site, however, clearly indicated the influences of ground water as water flowed from the outlet continuously. Throughout 1987 and 1988 during base flow, calcium was lower than alkalinity, and potassium was less than sodium indicative of a ground water source. Samples from June 17, 1987, August 4 and 5, 1987 and July 7, 1988 demonstrate these characteristics. Samples from June 28 and 29, 1987, and March/April 1988 clearly illustrate the influence of fertilizer inputs with calcium being greater than alkalinity and potassium greater than sodium. In these cases precipitation and migration down to the tile bed was the principal source for the tile flow. Base flow from a ground

water source was interspersed with tile flow due to precipitation.

Dinoseb was observed at this site in the spring of 1987, 7 months after it had been applied as a vine dessicant in September of 1986. Two observations were observed at concentrations of 0.17 and 0.20 μg/L. Dinoseb was applied as a pre-emergent herbicide on June 8, 1987. Four samples from June 17 did not indicate dinoseb presence, but five sequential samples on June 28th and 29th indicated dinoseb concentrations ranging from 0.06 to 0.57 μg/L. Three samples from September 14 and one from September 23 also contained dinoseb at concentrations of 0.44 to 0.05 μg/L. Samples in October and November of 1987 did not contain measurable concentrations of dinoseb. Six samples taken in the spring of 1988 (March/April) contained dinoseb at concentrations ranging from 0.02 to 0.07 μg/L, 10 months post-application, as did a single sample from September 8, 1988 at 0.02 μg/L. Samples from the 11th and 12th of April 1989 did not indicate dinoseb presence 22 months post application.

When looking at the dates dinoseb was detected, and the associated major ion chemistry it is readily apparent that dinoseb was observed at times when the principal source of tile effluent was from the soil above the tiles and not from ground water. Dinoseb was only detected in samples where the calcium was greater than alkalinity and potassium was greater than sodium thus confirming movement from the surface to a 1 metre depth. Of significance is the fact that dinoseb was detected at the same time as a chemical shift indicative of fertilizer use. This confirms that dinoseb migrated rapidly in the soils of the studied potato field.

Synopsis

All five sites illustrated that nutrients and pesticides were migrating from the soil surface and rootzone and were being transported to the tile bed 1 metre below the soil surface. It is characteristic for subsurface drainage to have high concentrations of nitrate-nitrogen and chloride, and for surface runoff to have high concentrations of ammonia-nitrogen and phosphorus (Overcash and Davidson, 1980). The concentrations of phosphorus from all study sites were at levels that would be considered acceptable for flow into lakes (McNeely *et al.*, 1979) and represent soil absorption. Smith *et al.* (1975) reported concentrations of nitrate as high as 99 mg/L in tile effluent from a study site in Illinois. Their data indicated that nitrate content had little correlation to times of application but rather with the quantities of flow from the tile drains. This implies the storage of nitrates in the soil matrix with removal by downward movement as a result of precipitation or irrigation. The high nitrates observed during the spring of 1987 and 1988 at Site R may be an example of a storage and release mechanism.

The pesticides dinoseb and metribuzin were both detected in the same season that they were applied and in the first major rain event to trigger significant tile flow. In both cases pesticide detection coincided with a shift of major ion chemistry indicative of fertilizer use. Additionally both were detected the following growing season during the spring when the soil matrix would be close to saturated conditions.

While the single maximum observed concentration of 44 μg/L is below the 96 hr LC_{50} values reported by Zitko *et al.* (1976) and Call *et al.* (1984), it is within the effect range reported by Woodward (1976), who determined a 96 hr LC_{50} to cutthroat (*Salmo clarki*) of 32 to 1400 μg/L (pH dependent). The highest toxicity was reported at a water pH of 6.5. It

was also reported, by Woodward, that yolk sac absorption and growth of lake trout fry (Salvelinus namaycush) was reduced in flow through tests at concentrations as low as 0.5 µg/L. Woodward (1976) expressed that, based upon his work, the maximum acceptable concentration for predicting safe concentrations in the aquatic environment would be below 0.5 µg/L for dinoseb.

Of the 173 dinoseb samples collected during the 2 years of study, 94 (54%) were greater than 0.02 µg/L. Twenty-seven of those 94 were above the 0.5 µg/L value determined by Woodward (1976). Though none of the studied tile outlets drained directly into a stream, the data indicate that observed dinoseb concentrations could have an impact, but any impact may be mitigated by the dilution capability of the receiving stream and the duration of flow.

The maximum estimated times that tile outflow exceeded 0.5 µg/L was 48 hours at Site R on April 1, 2 and 3, 1988, and 36 hours at Site R on September 22 and 23, 1987, 19 days post application. These times are a direct function of the sampling frequency used and are subject to temporal variability. Dependent upon when flow started prior to sample collection and how long it persisted after sample collection, exposure times may in fact be greater.

Metribuzin was the second pesticide on the project priority list that was detected in tile effluent post-application. Metribuzin is not, however, as toxic to fish as dinoseb with 96 hr LC_{50} concentrations greater than 100 ppm for rainbow trout and bluegill (Environment Canada, 1982). As with dinoseb, metribuzin was observed at the same time as a change in major ion chemistry indicating rapid movement through the soil column. Both pesticides displayed a first flush phenomenon where the highest concentrations were observed in the first samples collected post application.

The third chemical on the priority list was the fungicide chlorothalonil which was not applied at any of the sites in 1987. On a random basis, one site, O, was chosen for the analysis of chlorothalonil residues. Of eight samples collected on September 14 and 15, 1987, 3 displayed concentrations of chlorothalonil ranging from 2 to 3 times detection limit. These values are suspect as they were interspersed with values reported as less than the detection limit of 0.002 µg/L and the farmer did not indicate chlorothalonil use. The tile outlet and calibration flume at site O was adjacent to a secondary chipseal road and could have been affected by vehicular traffic. There is an adjoining field across the roadway belonging to another land owner. It is not inconceivable that there was some contamination of the flume by either spray drift from adjoining fields or by dust from the roadway. All other sampling sites were within protected wooded surroundings. In 1988 chlorothalonil was applied three times at Site B, but this did not become apparent until the 1988 crop history had been received. As a consequence no chlorothalonil samples were collected in 1988.

The synthetic pyrethroid cypermethrin was the only insecticide used on any of the five study fields in 1987. Cymbush 250 EC was applied at a rate of 0.15 L/ha on the 26th of July 1987 at site S. Eleven samples of tile effluent collected from August 3rd to 5th did not indicate any cypemethrin at the detection limit of 0.01 µg/L. This was not unexpected given that the synthetic pyrethroids as a group bind to soils and cypermethrin has displayed negligible soil mobility (NRCC, 1986). There is concern however for accidental overspray of water bodies and wetlands (NRCC, 1986). Fenvalerate and deltamethrin were not used in the study area and as a result were eliminated from the analytical protocol. However, when cypermethrin was quantitated no

spurious peaks were observed on the chromatograms that would indicate pyrethroid presence.

The last biocide identified by the Water Quality Branch was the chlorophenoxy herbicide MCPA. Chlorophenoxys have been used at some time on 4 of the study sites: 2,4-D at site R in 1984, MCPA at sites O and B in 1985, site P in 1983 and again at site O in 1986. Due to the reported mobility of 2,4-D, it was intended to quantitate MCPA as it had been cited on the 1987 crop production plans. However MCPA was not applied in 1987. As samples were being quantitated it became apparent that there was a matrix or solvent specific problem which prohibited the accurate quantitation of MCPA. MCPA, due to its low molecular weight relative to other phenoxys, elutes early after the solvent front on the gas chromatograph. There were also coextractives in this early part of the chromatogram that were masking and interfering with MCPA quantification. Ten MCPA samples from Site R were quantified in 1988 with all being less than detection limit.

Pesticide Transport

The presence of dinoseb in tile drainage effluent illustrates that the parent compound was migrating through one metre of soil and being intercepted by the tile system. Varying concentrations of dinoseb have been observed ranging from a minimum of less than detection to 44 μg/L. The concentrations greater than .5 μg/L are of concern due to the potential for a localized aquatic impact. However it is important on a mass balance basis to account for the total present in tile effluent as related to the total amount of dinoseb applied. In order to accurately describe the dinoseb mass balance, it would be necessary to quantify the amounts of pesticide present in several compartments: spray drift, volatilization at application, surface runoff, soil adsorption, microbial degradation, chemical degradation, plant

uptake, deep percolation and tile effluent. At best we can quantify only the amount of pesticide present in the tile effluent monitored, and delineate the observed levels and their environmental significance.

Yoo et al. (1981) reported that in a field investigation of the triazines cyanazine and procyazine, less than 0.01% of the herbicide losses were due to tile drainage removal. Muir and Baker (1976) reported parent and metabolite triazine losses in tile drainage in the vicinity of 0.15%.

Daily runoff data obtained from Agriculture Canada was formatted by Water Quality Branch EDP personnel so as to be compatable with the RS1 data management package. Conversion from mm/day to L/s was carried out so as to calculate pesticide export via the tile system. Though complete hydrographs were obtained, the pesticide samples collected represented only a few segments of any given hydrograph. In order to best describe the amount of dinoseb removed from site R and S the integrating techniques of Spencer et al. (1985) were used wherein the total pesticide losses were based on the average concentration and the total runoff for a given day. Where a single observation was recorded for a hydrograph a 24 hour output was used. Using this approach, Water Quality Branch observations accounted for 0.001% of the dinoseb at site R and less than 0.001% of the dinoseb at site S, as calculated by using the application rate, area of the field and amount of active ingredient.

In order to describe the worst case scenario, based on Branch data, the maximum recorded observation at site R and S was multiplied by the total volume of water that emanated from the respective outlets. This amount was again compared to the total applied and indicated that at site R, 0.3%, and at S, 0.03% of the dinoseb would be accounted for in tile effluent. As site S was affected by groundwater infusion, site R most

accurately reflects the potential tile-only export. Due to data gaps in the spring and fall it is difficult to accurately define the total amount of dinoseb removed through the tile system.

The total amount of dinoseb observed in the tile effluent was low as compared to the amount of active ingredient applied to each field. Overcash and Davidson (1980) report that pesticides in tile water are normally dilute and present primarily due to the low organic material content of the soil.

It would be concluded that the tile transport mechanism is accounting for only a small part of the total amount of dinoseb removed from field. Spray drift, volatilization, surface runoff, deep percolation, biochemical degradation and chemical degradation appear to be of greater significance than tile effluent alone. However, as there are 50,000 ha of agricultural land in the upper Saint John River valley under potato cultivation, the implications of deep percolation to shallow aquifers, are significant. The use of a highly soluble biocide on tile systems warrants further investigation into the potential for localized biological stress to a receiving aquatic system. Though the total amount of pesticide emanating from the tiles may be low compared to the net applied, it does represent an environmental input that may cause sub-lethal effects.

Subsurface drainage is a land improvement technique to make marginal land suitable for agriculture. What has been observed in tile drained fields may be extrapolated to untiled fields that have adequate drainage. Thus results from such studies indicate that there should be concern for ground water contamination.

Biological Sampling Results

Site S was observed to have a small pond and an old disposal pond suitable for phytoplankton and zooplankton population studies. Biological samples were collected by Branch staff on May 14, 26 and July 28, 1987 from the pond at the outlet and from the disposal site on May 26. Population identification was carried out under a 1987 PESTFUND contract. It was intended to collect a greater number of phytoplankton and zooplankton samples but the very dry mid-summer conditions and field quarantine curtailed sampling activities.

The sample from May 14th indicated various phytoplankton but no zooplankton, while the sample of May 26th displayed less diversity of phytoplankton and the presence of 5 zooplankton types. The sample of July 28th displayed a similar diversity but only 3 species from the previous collection. Navicula was the only phytoplankton cell that was seen in each of the three pond samples. The May 26th phytoplankton cells were pigmentless except for Cosmaria.

The one sample taken on May 26, 1987 from the disposal pond containing old pesticide containers displayed very limited phytoplankton, 2 vegetative species of Spirogyra, and very rarely Navicula which was present in the other sites. There were also no zooplankton observed at the disposal site.

Dinoseb had been applied on June 8th and was detected in the tile effluent on June 28th and 29th but was not detected in the pond on July 28th. Due to the limited biological samples collected it is impossible to identify a direct cause effect relationship but the few phyto-plankton and zoo-plankton species detected does warrant further study. Unfortunately this site was inaccessable in 1988 and this segment of the study could not continue.

Quality Assurance Results

In addition to standard internal laboratory quality assurance practices, duplicate samples were incorporated into the field collection of the samples. Four sets of duplicate and one set of triplicate samples for major ions were collected at random by the lay collectors representing 11% of the samples collected. There was good agreement on all parameters in the duplicates and triplicates. All samples collected during the spring of 1989 were duplicates with two sets of triplicates.

Quality assurance for the pesticide analyses consisted of laboratory spikes, blanks, field spikes, and duplicates. Seven sets of triplicate samples were used in the pesticide aspect of the study. There was good agreement within each set of triplicates. There were also 5 dinoseb spiked samples, that when quantified yielded 47.5%, 90%, 65%, 81%, and 73% recoveries of dinoseb. Dinoseb was spiked into field collected samples at a concentration an order of magnitude above the detection limit of 0.02 μg/L and in the operational ranges observed. Where actual concentrations were reported above this range the samples were diluted so as to be in the linear range of detector response. Two metribuzin field spikes were reported as 100% and 120% recoveries. The triplicates and spiked samples accounted for 16% of the toxic chemical samples.

RECOMMENDATIONS

This joint project has illustrated that federal and provincial departments can co-operate on a mutually beneficial project in an effective manner. Close co-operation has resulted in a large amount of data being generated in various technical realms. The sharing of expertise has been of benefit to all parties involved and should be continued.

Carry over of the herbicides dinoseb and metribuzin in the soil matrix from one growing season to the following has been observed. The action of tile drainage in low organic soils is that the tile system intercepts downward moving residues, thus providing a means to assess potential surface and ground water effects. The concentrations of dinoseb that have been observed ranged from 44 µg/L to less than 0.02 µg/L. The single observation of 44 µg/L of dinoseb in tile effluent is in the high end of the concentration range cited by Call et al. (1984) and might cause localized biological effect in the immediate vicinity of the tile outlet. The extent of any effect would be dependent upon the size and dilution capability of any receiving water course, and the duration of the input level. The total amount of parent dinoseb removed by the tile system as calculated from Branch observations accounts for only 0.001% of the parent compound that was applied to the two sites. Metribuzin observations also indicated rapid movement to the tile system as a result of post-application precipitation events.

The concentrations of nitrate and total nitrogen leaving the fields is of importance to the farmer and indicates the need for further agricultural studies into fertilizer application rates and frequency. Impacts of nitrate loading would also be dependent upon the dilution capability of a receiving water body but does indicate potential problems for small aquatic systems and shallow aquifers.

The maximum observed concentration for dinoseb was 44 µg/L while 16 other observations were between 1.0 and 5.1 µg/L. Health and Welfare Canada has issued a guidance value for dinoseb of 10 µg/L. The Guidelines for Canadian Drinking Water (Health and Welfare Canada, 1987) specify a maximum acceptable concentration for metribuzin of 80 µg/L. The maximum concentration observed for metribuzin was 1.5 µg/L or 1.8% of the maximum acceptable concentration. On numerous occasions the concentrations of nitrate-nitrogen exceeded the 10 mg/L maximum acceptable concentration of the Guidelines for Canadian Drinking Water Quality (Health and Welfare Canada, 1987).

Admittedly, the tile effluent was not used as a source of drinking water. However, the concentrations of dinoseb and nitrate observed indicate a real concern for shallow aquifers and untiled areas of good natural drainage.

Though the tile system provides a mechanism for water removal in lands of marginal use, it also serves as an indicator of the leachability of pesticides in agricultural use in the potato growing region of the Saint John River Valley. Nutrients and pesticides leaving the root zone are being integrated by the tile system. Pesticides can leave the root zone and may move to ground water. The presence of the tiles merely reflects the processes that would occur on fields that are naturally well drained. As a result the use of tiled fields may be warranted during the pre-registration evaluation of pesticides in Canada for determining leachability.

The use of tile systems during the post-registration process is of obvious merit in order to determine the mobility of in-use active ingredients under normal use patterns under Maritime conditions.

The results thus far lead to four areas where further work is warranted.

1) The movement of nutrients and pesticides from the root zone has been documented on a field scale with obvious implications to ground water. This project has provided scientific support to a concurrent Inland Waters Directorate study into aquifer vulnerability. Every effort should be made to ensure that future projects are mutually complementary.

2) Quantifiable concentrations of pesticides have been observed in tile effluent. The effects of this effluent upon a receiving aquatic system has not been studied. The project should be continued with an expansion into the measurement of ecosystem response.

3) This study has resulted in the first water quality evaluation of tile drain water in Atlantic Canada. There is still a need to study the water quality effects of different crops, rotations, soils and pesticides. Pesticide information produced from this study should be part of the Agriculture Canada pesticide post-registration process.

4) Agriculture Canada, Environment Canada and the provincial departments of agriculture should continue to participate in co-operative projects given the importance of sustainable agriculture and sustainable development. Research needs to continue into improving agicultural production and viability without environmental cost.

The use of tile drainage is an agricultural necessity and co-incidentally, provides a mechanism by which pesticide movement may be verified. The challenge facing the environmental and agricultural sectors is to determine which agricultural practices will have the least impact upon ground waters and how these practices may be employed. Tile drainage provides a means of assessing these practices.

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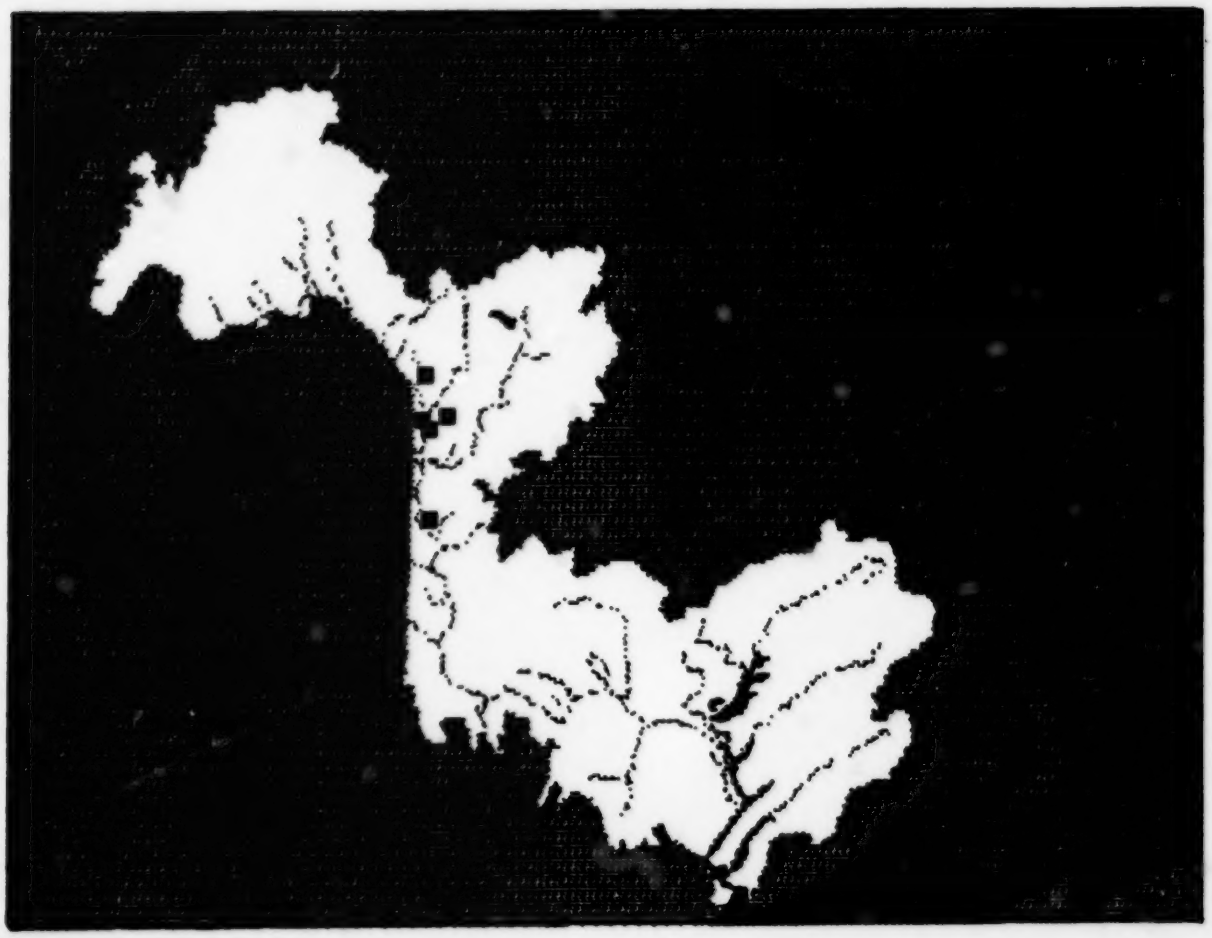
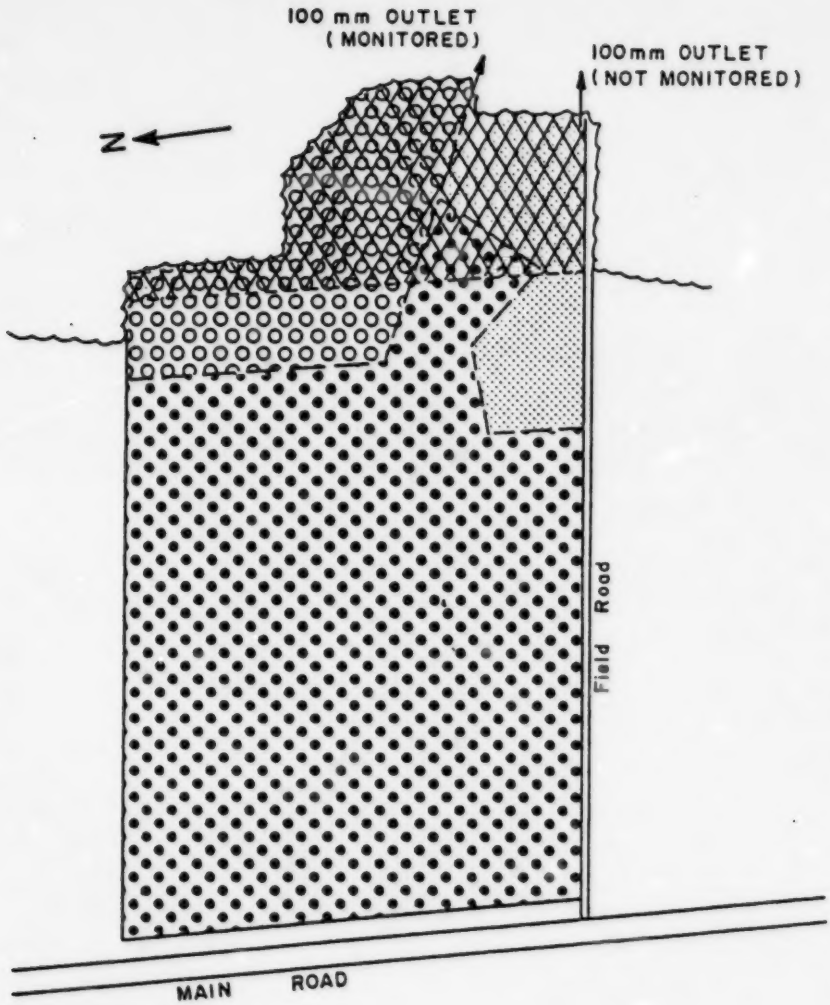
FIGURE: 1

LOCATION OF TILE SITES (■) IN THE

SAINT JOHN RIVER BASIN





ooooo SUBDRAINED AREA, 3.1 ha (MONITORED)

SUBDRAINED AREA, 1.9 ha (NOT MONITORED)

•••••• UNDRAINED AREA, 14.8 ha

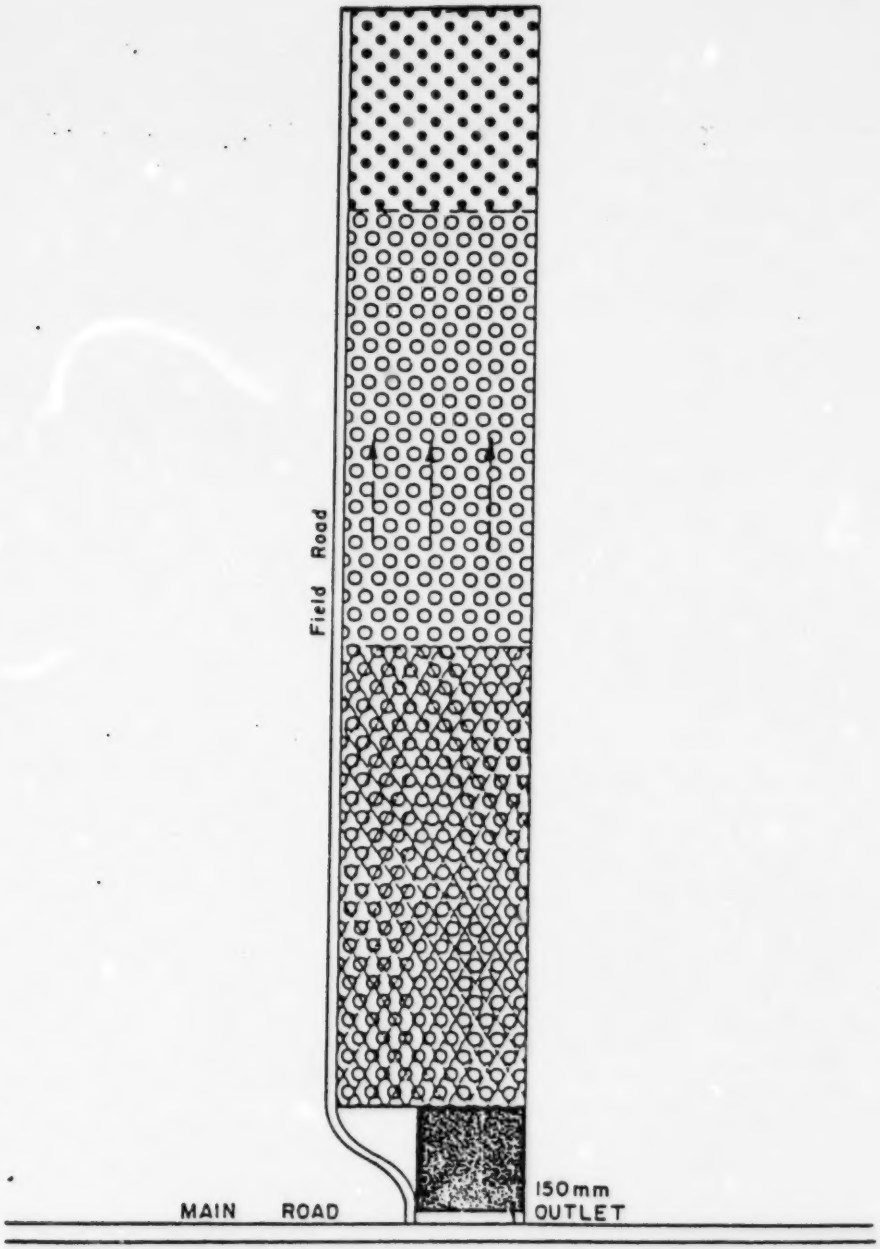
XXXXX USED ONLY FOR HAY PRIOR TO DRAINAGE, 3.3 ha

1986 ROW DIRECTION

WOODS

SCALE 1:5000

FIGURE 2: SITE 'B' FIELD PLAN



AREA NOT SEEDED IN 1987 0.6ha (BARLEY)

oooooo SUBDRAINED AREA , 10.4ha

•••••• UNDRAINED AREA , 3.2 ha

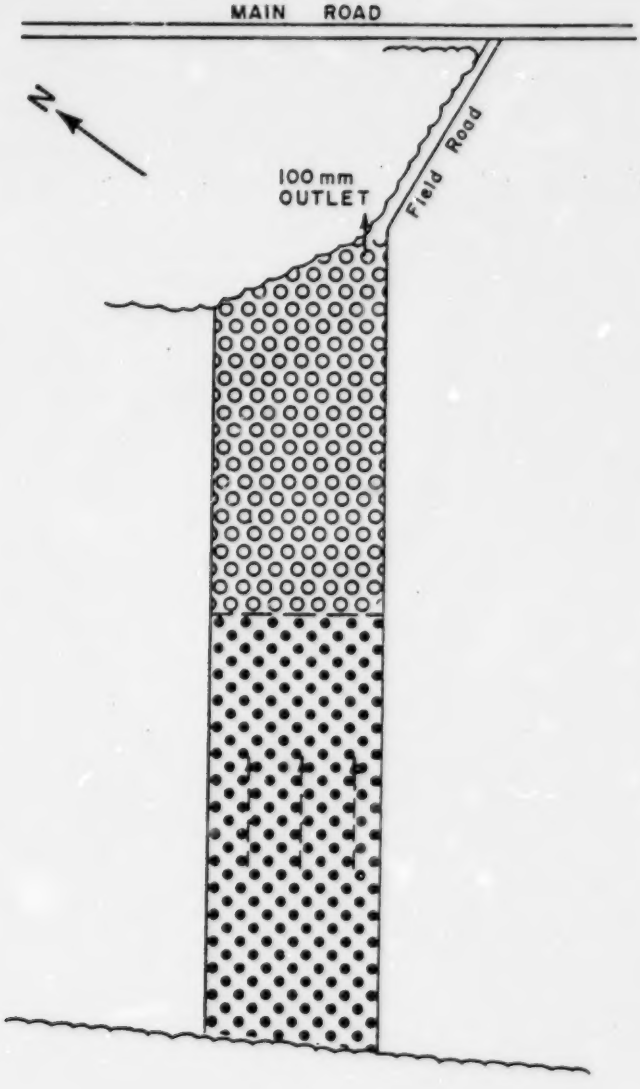
XXXXX PASTURE PRIOR TO DRAINAGE , 6.0ha

1986 ROW DIRECTION

WOODS

SCALE 1:5000

FIGURE 3: SITE 'O' FIELD PLAN



ooooo SUBDRAINED AREA , 3.0 ha

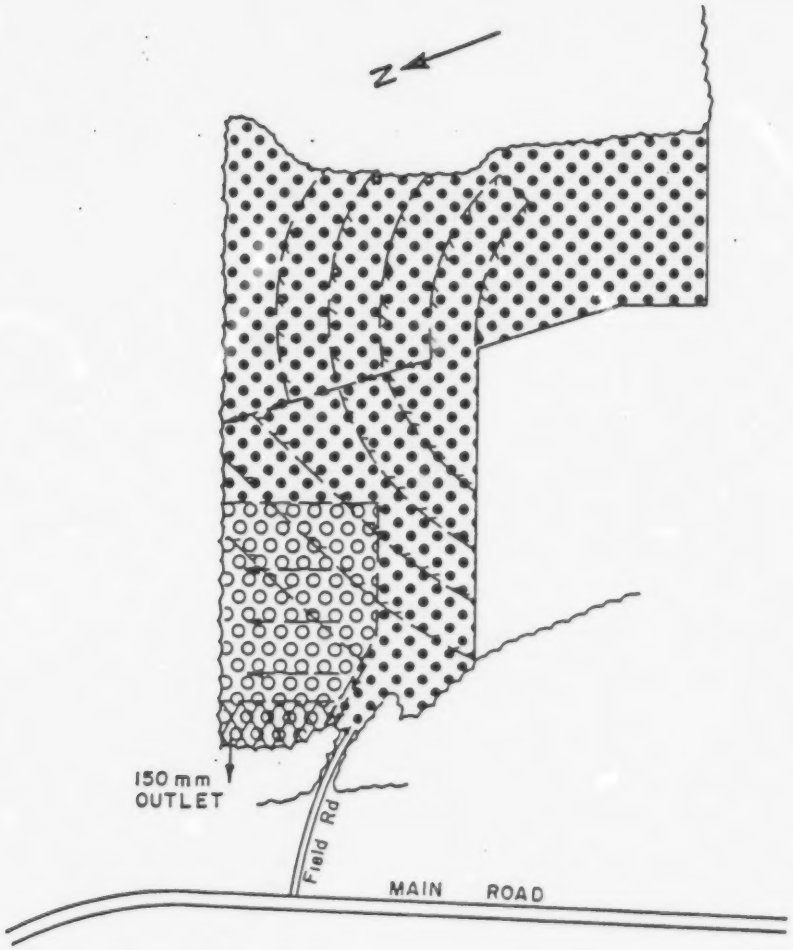
•••••• UNDRAINED AREA , 5.7 ha

1986 ROW DIRECTION

WOODS

SCALE 1:5000

FIGURE 4: SITE 'P' FIELD PLAN



ooooo SUBDRAINED AREA , 7.7 ha

●●●●●● UNDRAINED AREA , 22.7 ha

'XXXXX' TO WET TO FARM 1982 - 83 , 2.0ha

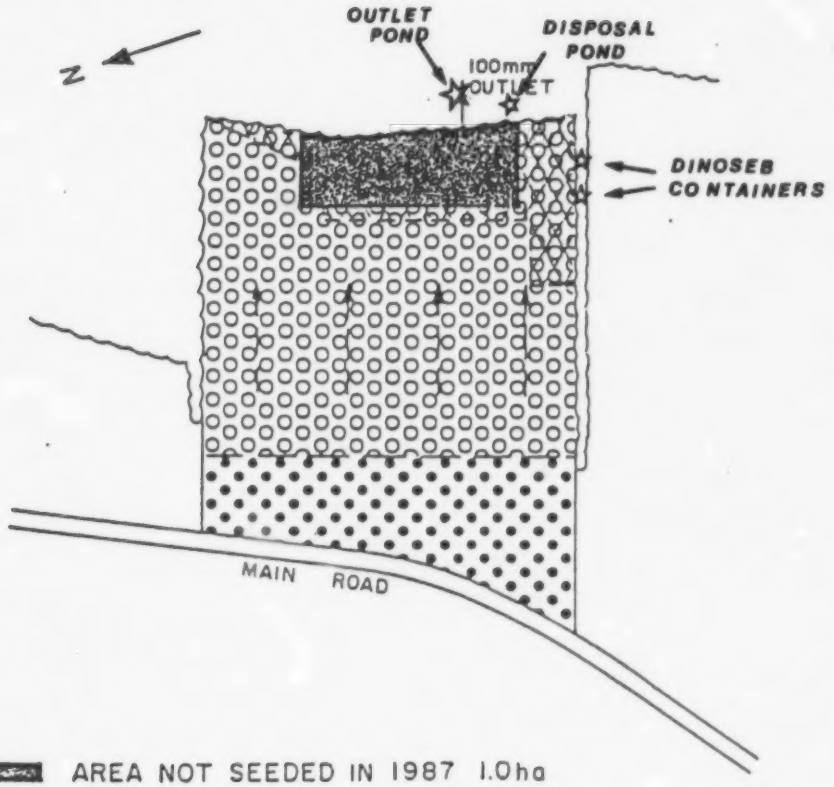
DIVERSION TERRACE (CONSTRUCTED FALL, 1986)

ROW DIRECTION PRIOR TO TERRACING

WOODS

SCALE 1 : 10,000

FIGURE 5 : SITE 'R' FIELD PLAN



AREA NOT SEEDED IN 1987 1.0ha

ooooo SUBDRAINED AREA , 7.3ha

• • • • UNDRAINED AREA , 2.4 ha

XXXXX NOT FARMED PRIOR TO DRAINAGE , 1.6 ha

1986 ROW DIRECTION

WOODS

SCALE 1:5000

FIGURE 6: SITE 'S' FIELD PLAN

TABLE 1

NAQUADAT Station Number and

Description of Study Sites

NAQUADAT Station Number	Site Description	Site Designation
13NB01AF0001	Tile Drainage Outlet	O
13NB01AF0002	Tile Drainage Outlet	R
13NB01AF0003	Tile Drainage Outlet	P
13NB01AG0001	Tile Drainage Outlet	S
13NB01AJ0001	Tile Drainage Outlet	B

TABLE 2

Soil Characteristics of Study Sites

Site No.	Soil Series*	Particle Size Distribution* Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Depth to Compact Layer* (cm)	Organic Carbon * (g kg^{-1})	Canadian Classification System*	U.S. System
1 (S)	Holmsville	-	-	-	30 - 60	-	Orthic Humo-Ferric Podzol	Typic Cryorthods
2 (R)	Holmsville	410	490	10	30 - 60	23	Orthic Humo-Ferric Podzol	Typic Cryorthods
3 (P)	Holmsville	440	430	130	30 - 60	19	Orthic Humo-Ferric Podzol	Typic Cryorthods
4 (B)	Carleton	350	500	150	30 - 100	33	Orthic Humo-Ferric Podzol	Typic Cryorthods
5 (O)	Siegas	260	560	180	30 - 60	29	Podzolic Gray Luvisol	Mollic Cryoboralfs

* Refer Fahmy et. al. (1986)

* 0-15 cm depth; average of eight field samples

TABLE 3

Summary of Anticipated 1987 Crop Production Plans and Pesticide Application Frequency Based on 1986 Applications

Site / Crop	R Seed Potatoes	S 50% Potatoe 50% grain
Month		
May	1 x Dinoseb 1 x Paraquat	1 x Dinoseb
June		1 x MCPA
July	2 x Mancozeb 1 x Deltamethrin	3 x Chlorothalonil
August	4 x Mancozeb	5 x Chlorothalonil 1 x Fenvalerate
September	1 x Mancozeb 1 x Diquat	1 x Metalaxyl + Mancozeb 1 x Chlorothalonil 1 x Diquat 1 x Dinoseb

Site / Crop	P Seed Grain	O Process Potatoes	B Red Clover
Month			
May		1 x Metribuzin	No Pesticides
June	1 x MCPA	4 x Mancozeb	"
July		4 x Mancozeb 1 x Sethoxydim + Assist	"
August		4 x Mancozeb 2 x Metalaxyl	"
September		1 x Diquat	"

TABLE 4

Pesticide of Interest, Chemical Name and NAQUADAT Parameter Code

Pesticide	Type	Chemical Name	Parameter Code
PRIORITY I			
(1) Dinoseb	(H)	2-Sec-butyl-4,6-dinitrophenol	89825
(2) Metribuzin	(H)	4-Amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one	89820
(3) Chlorothalonil	(F)	Tetrachloroisophthalonitrile	89985
PRIORITY II			
(4) Fenvalerate	(I)	Cyano (3-phenoxybenzyl) methyl 4-chloro-alpha (1-methyl ethyl) benzene/acetate	89370
(5) Deltamethrin	(I)	Cyano (3-phenoxybenzyl)-cis-3-(2,2-dibromovinyl)-2-2-dimethyl cyclopropane carboxylate	89360
(6) MCPA	(H)	4-Chloro-2-methyl phenoxyacetic acid	89410

NOTE: Type (H) Herbicide, (F) Fungicide, (I) Insecticide

TABLE 5

Major Ion, and Nutrient Parameters with NAQUADAT Parameter Codes

Color	02011
Calcium	20110
Alkalinity	10101
Turbidity	02073
Magnesium	12107
Potassium	19103
Sodium	11103
pH	10301
Chloride I.C.	17209
Sulphate MTB	16304
Sulphate I.C.	16309
Silica	14102
Specific Conductance	02041
Dissolved Organic Carbon	06107
Nitrate + Nitrite	07110
Total Nitrogen	07601
Total Phosphorus	15413
Non-filterable Residue	10401

TABLE 6

HISTORICAL PRECIPITATION DATA
GRAND FALLS, N. B.

TOTAL MONTHLY PRECIPITATION (Amirault 1987)
in Millimetres

	1982	1983	1984	1985	1986
May	11.8	133.0	172.0	103.0	60.0
June	83.9	16.0	170.0	116.0	58.0
July	127.5	162.0	134.7	204.0	113.0
August	143.0	120.0	52.0	50.0	150.0
September	124.0	114.0	53.0	75.0	109.0
October	46.0	50.0	51.0	40.0	53.0

TABLE 7:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE B

	SDATE	STIME	89825L DINOSEB	89820L METRIBUZIN	02011L COLOR	20110L CALCIUM	10101L ALK.	02073L TURBID.	12107L Mg	19103L K	11103L Na	10301L pH	17209L Cl / IC
1	07-APR-87	1330	L.02	0.020									
2	08-APR-87	1231	L.02	0.020	10	16.0	30.7	4.2	3.3	0.58	1.2	7.1	1.6
3	07-MAY-87	1056	L.02	0.010	35	16.0	27.1	17.0	3.0	0.63	1.4	7.2	1.7
4	07-MAY-87	1553	L.02	0.010	15	17.0	29.0	7.5	3.0	0.55	1.4	7.3	1.7
5	07-MAY-87	1951	L.02	0.010	10	17.0	28.6	6.0	3.0	0.58	1.4	7.4	1.7
6	07-MAY-87	2346	L.02	0.010	10	17.0	27.7	5.0	3.0	0.58	1.4	7.4	1.6
7	05-NOV-87	700	L.02	0.003									
8	05-NOV-87	701	L.02	0.003	25	14.6	28.0	11.0	2.4	0.46	1.4	6.8	0.5
9	05-NOV-87	1101	L.02	0.001	25	14.7	27.8	10.0	2.4	0.46	1.4	6.9	0.5
10	05-NOV-87	1501	L.02	0.002	25	14.9	28.4	9.2	2.4	0.46	1.4	6.9	0.5
11	05-NOV-87	1901	L.02	0.001	25	14.9	26.7	9.6	2.4	0.46	1.4	7.2	L.5
12	28-MAR-88	1701	L.02		50	9.6	23.4	9.0	2.1	0.54	0.6	6.7	L.5
13	31-MAR-88	1701	L.02		70	11.0	25.9	17.0	2.3	0.64	0.7	6.9	0.5
14	01-APR-88	838	L.02		35	15.0	33.1	8.1	2.5	0.49	1.0	7.0	0.9
15	02-APR-88	831	L.02		30	16.0	34.6	7.2	2.6	0.47	1.0	7.2	0.9
16	03-APR-88	853	L.02		25	17.0	37.0	6.5	2.6	0.49	1.1	7.0	1.3
17	04-APR-88	826	L.02		20	18.0	38.2	5.6	2.7	0.51	1.1	7.0	1.7
18	30-APR-88	1725	L.02	L.007	15	13.7	25.8	6.0	2.6	0.54	1.3	7.4	0.7
19	01-MAY-88	735	L.02	L.003	15	13.8	25.8	5.0	2.6	0.51	1.3	7.7	0.6
20	01-MAY-88	1145	L.02	L.003	15	13.8	25.6	5.6	2.6	0.52	1.3	7.4	0.6
21	01-MAY-88	1539	L.02	0.004	15	14.0	26.1	4.8	2.6	0.52	1.3	7.3	0.6
22	08-AUG-88	731		1.534	5	56.0	20.0	2.2	12.0	1.70	2.9	7.1	60.0
23	08-AUG-88	1131		0.608	L5.	50.0	21.5	1.5	11.0	1.50	2.8	7.1	50.0
24	08-AUG-88	1531		0.985	L5.	48.0	23.1	1.5	10.0	1.40	2.7	7.1	45.0
25	08-AUG-88	1931		0.419	5	47.0	22.6	1.5	10.0	1.40	2.7	7.1	45.0
26	08-AUG-88	2331		0.563	L5.	47.0	23.2	1.2	10.0	1.40	2.7	7.1	45.0
27	09-AUG-88	721		0.679	L5.	44.0	25.0	0.9	9.3	1.30	2.7	7.2	41.0
28	09-AUG-88	1121		0.938	L5.	44.0	25.4	0.9	8.9	1.30	2.7	7.4	41.0
29	09-AUG-88	1521		0.850	5	43.0	28.1	1.5	8.6	1.30	2.7	7.2	38.0
30	09-AUG-88	1911		0.708	L5.	43.0	27.1	1.1	8.4	1.20	2.7	7.2	37.0
31	19-OCT-88	1221		0.305	L5.	48.0	13.4	1.5	9.8	1.10	2.5	6.6	44.0
32	19-OCT-88	1601		0.235	L5.	47.0	13.9	0.9	9.7	1.20	2.6	6.7	45.0
33	19-OCT-88	1931		0.164	L5.	47.0	13.6	0.9	9.6	1.20	2.6	6.7	45.0
34	07-NOV-88	801		0.057	10	33.0	25.8	5.9	6.5	0.70	2.0	6.8	27.0
35	07-NOV-88	1226		0.061		25.0	25.0	25.0	4.9	0.73	2.0	6.8	26.5
36	07-NOV-88	1626		0.087	5	14.0	22.6	5.0	2.6	0.60	1.8	6.9	23.6
37	08-NOV-88	701		0.232	50	16.0	12.4	17.0	3.4	0.58	1.0	6.6	14.9
38	08-NOV-88	1101		0.239	40	16.0	14.9	11.0	3.1	0.57	0.9	6.8	13.3
39	08-NOV-88	1601		0.199	40	31.0	21.9	10.0	6.5	0.94	1.9	6.6	28.0
40	09-NOV-88	801		0.391		22.0	18.2	29.0	4.9	1.40	1.6	6.6	23.5
41	09-NOV-88	1202		0.240	30	21.0	17.0	8.6	4.7	0.79	1.3	6.7	20.1
42	11-APR-89	1100		0.263									
43	11-APR-89	1101		0.305	15	16.0	23.0	4.4	4.4	1.50	1.1	7.0	13.9
44	12-APR-89	956		0.158	15	17.0	24.6	4.5	4.3	1.30	1.3	7.0	13.9
45	12-APR-89	957		0.143									

TABLE 7:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE B

	SDATE	16304L SO4 /MTB	16309L SO4 /IC	14102L Si	02041L SP.COND.	06107L DOC	07110L NO3 + NO2	07601L TOT. N	15413L PO4	10401L RESIDUE
1	07-APR-87									
2	08-APR-87	8.2	7.5	3.70	116	3.8	3.00	3.00	0.047	
3	07-MAY-87	11.1	11.4	5.09	118	3.2	3.40	3.40	0.045	
4	07-MAY-87	11.3	11.4	4.99	123	3.2	3.80	3.90	0.037	
5	07-MAY-87	11.5	11.9	5.24	123	3.4	3.80	4.30	0.038	
6	07-MAY-87	11.5	11.9	4.99	123	2.8	3.80	4.50	0.036	
7	05-NOV-87									
8	05-NOV-87	15.9	15.6	5.50	104	3.6	0.72	0.73	0.047	L10.
9	05-NOV-87	15.7	15.6	5.50	103	3.8	0.70	0.73	0.045	L10.
10	05-NOV-87	15.7	15.5	5.50	104	3.8	0.68	0.74	0.051	L10.
11	05-NOV-87	15.7	15.5	5.40	103	3.9	0.73	0.72	0.042	L10.
12	28-MAR-88	4.0	3.6	1.80	69	7.0	0.90	1.30	0.110	
13	31-MAR-88	4.9	4.5	2.33	78	7.2	0.80	1.20	0.140	
14	01-APR-88	6.6	6.2	3.02	102	5.8	1.40	1.60	0.040	
15	02-APR-88	6.8	6.5	3.18	106	5.5	1.60	2.20	0.040	
16	03-APR-88	7.4	7.2	3.39	115	4.9	1.80	2.10	0.040	
17	04-APR-88	7.9	7.7	3.56	123	4.7	2.20	2.40	0.030	
18	30-APR-88	10.8	11.0	1.37	103	3.2	2.80	2.80	0.037	L10.
19	01-MAY-88	10.9	10.5	4.68	103	3.2	2.60	2.60	0.038	L10.
20	01-MAY-88	11.1	10.6	4.55	103	3.2	2.70	2.70	0.038	L10.
21	01-MAY-88	11.1	10.7	4.70	104	3.4	2.80	2.80	0.036	
22	08-AUG-88	26.2	25.5	7.40	459	5.0	24.00	26.50	0.050	
23	08-AUG-88	21.2	20.5	7.70	415	4.4	21.00	27.50	0.051	
24	08-AUG-88	18.1	17.7	8.00	382	3.5	17.00	24.00	0.039	
25	08-AUG-88	18.3	17.5	8.00	382	4.2	17.00	18.00	0.047	
26	08-AUG-88	17.6	17.0	8.00	380	4.1	22.00	24.00	0.044	
27	09-AUG-88	15.9	15.1	8.30	355	3.6	19.00	22.00	0.038	
28	09-AUG-88	15.4	14.8	8.30	348	3.8	15.00	22.50	0.041	
29	09-AUG-88	14.8	14.2	8.60	340	3.8	13.00	21.00	0.036	
30	09-AUG-88	14.8	14.1	8.60	332	3.6	13.00	19.50	0.038	
31	19-OCT-88	12.1	11.5	4.80	373	2.0	22.00	23.00	0.028	
32	19-OCT-88	11.9	11.5	4.80	369	1.8	22.00	22.00	0.026	
33	19-OCT-88	12.1	11.8	5.00	368	1.8	22.00	23.00	0.029	
34	07-NOV-88	11.2	10.9	5.00	263	4.0	10.40	11.00	0.030	
35	07-NOV-88	11.1	10.2	4.80	256	8.6	9.80	13.00	0.060	
36	07-NOV-88	9.7	9.1	4.30	229	8.5	8.70	9.50	0.042	
37	08-NOV-88	5.8	5.2	2.00	133	2.6	4.20	5.00	0.130	
38	08-NOV-88	5.3	5.0	2.50	128	2.6	4.20	4.60	0.110	
39	08-NOV-88	10.6	9.7	4.20	250	9.4	10.00	12.00	0.070	
40	09-NOV-88	9.4	8.7	3.20	214	13.0	8.80	13.00	0.100	
41	09-NOV-88	7.5	6.5	2.70	177	2.6	7.60	10.00	0.060	
42	11-APR-89									
43	11-APR-89	7.1	6.7	2.20	140	3.7	4.10	4.10	0.100	
44	12-APR-89	7.0	6.4	2.70	147	3.0	4.30	4.30	0.046	
45	12-APR-89									

TABLE 8:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE 0

	SDATE	STIME	89825L DINOSEB	89820L METRIBUZIN	89985L CHLOROTHALONIL		02011L COLOR		20110L CALCIUM	10101L ALK.	02073L TURBID.	12107L Mg	19103L K	11103L Na
1	07-APR-87	1600		0.02										
2	08-APR-87	831		L.01				5	18.0	16.4	2.9	3.4	1.7	1.1
3	17-JUN-87	1105		L.01				5	36.0	41.8	6.4	4.0	4.1	2.2
4	17-JUN-87	1440		L.01			L5.		37.0	43.4	1.7	4.0	3.0	2.2
5	17-JUN-87	1635		L.01			L5.		36.0	43.7	3.8	4.0	3.1	2.2
6	17-JUN-87	2035		L.01				5	38.0	44.0	4.7	4.1	3.3	2.2
7	28-JUN-87	1506		L.01			L5.		47.0	21.6	2.6	6.8	4.1	2.8
8	28-JUN-87	1508		L.01			L5.		47.0	21.4	3.2	6.8	4.1	2.7
9	28-JUN-87	1815		0.01					56.0	6.5	28.0	8.5	8.8	2.8
10	28-JUN-87	2210		L.01				5	54.0	15.7	2.9	8.4	6.2	2.9
11	29-JUN-87	115		L.01				5	51.0	19.4	2.3	7.9	5.1	2.9
12	29-JUN-87	425					L5.		49.0	22.1	2.8	7.5	5.0	2.9
13	29-JUN-87	640	L.02				L5.		48.0	24.2	1.5	7.3	4.4	2.8
14	29-JUN-87	1300					L5.		44.0	27.4	1.8	6.7	3.6	3.0
15	29-JUN-87	1500					L5.		43.0	30.3	1.6	6.0	3.0	2.8
16	29-JUN-87	2000					L5.		40.0	33.1	1.8	5.4	2.8	2.8
17	30-JUN-87	425					L5.		37.0	34.3	1.6	4.6	2.2	2.7
18	30-JUN-87	1240					L5.		38.0	33.8	1.7	4.8	2.4	2.7
19	03-AUG-87	450	0.02					50	35.7	23.8	32.0	5.3	2.8	2.9
20	03-AUG-87	830	L.02					5	41.0	27.8	8.7	5.9	2.8	2.9
21	03-AUG-87	2430	L.02					5	41.0	30.0	4.1	5.9	2.4	2.9
22	04-AUG-87	426	L.02				L5.		43.0	40.8	1.7	5.5	2.0	3.0
23	04-AUG-87	431	L.02					5	42.0	33.4	4.5	5.9	2.3	3.0
24	04-AUG-87	821	L.02				L5.		43.0	42.9	1.7	5.4	2.0	3.1
25	04-AUG-87	831	L.02				L5.		42.0	35.6	1.0	5.8	2.2	3.0
26	04-AUG-87	1231	L.02				L5.		43.0	45.0	2.8	5.4	2.0	3.0
27	04-AUG-87	1246	L.02				L5.		43.0	37.9	2.2	5.7	2.1	3.1
28	05-AUG-87	831	L.02				L5.		43.0	46.3	2.2	5.4	2.0	3.0
29	05-AUG-87	1230	L.02				L5.		43.0	45.5	2.7	5.4	2.0	3.0
30	05-AUG-87	1316	L.02				L5.		43.0	47.3	1.5	5.3	1.8	3.0
31	14-SEP-87	801			L.002		L5.		40.6	32.0	1.3	5.8	3.3	2.8
32	14-SEP-87	1202			L.002		L5.		40.4	34.7	1.5	5.8	3.2	2.9
33	14-SEP-87	1531				0.005	L5.		38.9	28.3	2.2	5.7	3.3	2.7
34	15-SEP-87	402				0.007	L5.		41.4	43.0	1.4	5.4	3.0	3.0
35	15-SEP-87	403			L.002		L5.		40.8	37.3	1.2	5.7	3.1	3.0
36	15-SEP-87	802			L.002		L5.		41.2	39.1	0.7	5.5	3.0	3.0
37	15-SEP-87	803				0.004	L5.		42.1	43.9	2.5	5.3	2.7	3.0
38	15-SEP-87	1202			L.002		L5.		41.4	40.1	0.7	5.5	3.0	3.0
39	22-SEP-87	400		L.01										
40	22-SEP-87	830		L.01			L5.		37.7	32.7	1.7	6.0	3.0	2.9
41	22-SEP-87	900		L.01			L5.		37.9	35.1	1.6	6.0	3.1	2.9
42	22-SEP-87	1205					L5.		37.9	34.2	1.5	6.1	3.2	2.9
43	22-SEP-87	1600					L5.		37.7	34.7	1.3	6.0	2.9	3.0
44	28-MAR-88	1131	L.02					10	12.0	7.1	5.2	2.4	2.8	0.8
45	29-MAR-88	1656	L.02					5	22.0	13.6	3.2	3.8	4.6	1.4
46	31-MAR-88	1311	L.02					30	19.0	13.0	15.0	3.7	4.3	1.2
47	01-APR-88	1121	L.02					10	17.0	11.0	5.9	3.2	3.1	1.1
48	02-APR-88	1056	L.02					10	17.0	11.6	4.9	3.3	3.6	1.1
49	01-MAY-88	1435	L.02				L5.		30.9	32.0	1.7	4.6	5.0	2.0
50	01-MAY-88	1810	L.02				L5.		30.9	31.6	1.0	4.5	5.2	2.3
51	01-MAY-88	2210	L.02				L5.		30.9	31.3	0.7	4.5	4.2	2.1
52	02-MAY-88	155	L.02				L5.		31.0	29.9	1.4	4.5	3.8	2.1

TABLE 8:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE 0

	SDATE	10301L pH	17209L Cl / IC	16304L SO4 /MTB	16309L SO4 /IC	14102L Si	02041L SP.COND.	06107L DOC	07110L NO3 + NO2	07601L TOT. N	15413L PO4	10401L RESIDUE
1	07-APR-87											
2	08-APR-87	7.0	12.0	5.6	4.9	2.95	156	3.4	6.8	6.8	0.040	
3	17-JUN-87	7.4	10.1	4.6	3.8	6.72	260	1.2	19.0	29.0	0.027	
4	17-JUN-87	7.3	10.0	4.6	3.9	7.04	263	1.5	18.0	26.0	0.033	
5	17-JUN-87	7.3	10.1	4.5	3.9	6.21	263	1.4	18.0	18.0	0.018	
6	17-JUN-87	7.3	10.1	4.5	3.9	5.80	267	1.5	19.0	27.0	0.018	
7	28-JUN-87	7.1	22.0	8.2	7.9	7.10	361	2.2	29.0	29.0		
8	28-JUN-87	7.1	22.0	8.2	7.3	7.20	360	2.0	29.0	28.0		
9	28-JUN-87	6.2	31.0	15.2	14.0	5.48	440	3.2	36.0	39.0		
10	28-JUN-87	6.7	28.0	11.4	9.5	6.08	414	2.7	34.0	35.0		
11	29-JUN-87	6.7	25.0	9.6	8.5	6.51	388	2.4	31.0	32.0		
12	29-JUN-87	7.0	23.0	9.0	8.2	6.66	371	2.2	30.0	30.0		
13	29-JUN-87	7.0	22.6	8.7	7.8	6.78	362	2.0	29.0	29.0		
14	29-JUN-87	7.3	20.0	7.4	7.2	6.83	354	1.8	27.0	35.0	0.019	
15	29-JUN-87	7.5	18.3	4.1	6.4	7.02	331	2.2	25.0	32.0	0.023	
16	29-JUN-87	7.5	15.8	5.8	5.5	7.00	304	1.6	23.0	23.0	0.018	
17	30-JUN-87	7.7	13.3	5.0	4.6	6.98	275	1.8	20.0	19.0	0.019	
18	30-JUN-87	7.7	14.0	5.3	4.9	7.10	285	1.8	21.0	19.0	0.016	
19	03-AUG-87	7.4	13.4	8.7	8.0	7.30	286	3.4	20.0	20.0	0.130	
20	03-AUG-87	7.6	16.4	7.1	6.8	8.80	317	2.6	23.0	23.0	0.034	
21	03-AUG-87	7.7	16.7	6.8	6.6	9.20	319	2.1	24.0	24.0		
22	04-AUG-87	7.2	15.2	5.8	5.6	10.10	314	1.8	21.0	24.0	0.013	
23	04-AUG-87	7.5	16.2	6.9	6.4	9.60	321	1.8	23.0	23.0	0.015	
24	04-AUG-87	7.5	14.7	5.4	5.5	10.10	312	1.4	20.0	20.0	0.013	
25	04-AUG-87	7.2	16.1	6.5	6.4	9.60	320	1.8	22.0	22.0	0.016	
26	04-AUG-87	7.4	14.7	5.4	5.6	9.60	317	1.6	20.0	20.0	0.020	
27	04-AUG-87	7.6	15.6	6.1	6.0	10.10	317	1.7	23.5	26.0	0.015	
28	05-AUG-87	7.9	14.5	5.2	5.1	9.60	321	1.6	20.0	23.0	0.013	
29	05-AUG-87	7.6	14.7	5.4	5.3	9.60	319	1.6	21.0	26.0	0.015	
30	05-AUG-87	8.0	14.3	4.8	4.8	8.80	317	1.8	20.0	23.0	0.012	
31	14-SEP-87	6.7	16.9	8.5	7.8	8.20	309	2.4	21.0	28.0	0.023	
32	14-SEP-87	7.0	16.2	8.1	7.7	8.20	311	2.3	21.0	36.0	0.020	L10.
33	14-SEP-87	6.7	17.2	8.5	8.0	8.20	304	2.7	21.0	24.0	0.042	L10.
34	15-SEP-87	7.2	15.3	7.1	6.5	8.50	314	1.9	21.0	21.0	0.020	L10.
35	15-SEP-87	7.1	16.1	7.9	7.4	8.50	311	2.2	21.0	21.0	0.018	
36	15-SEP-87	7.3	15.5	7.5	6.9	8.50	313	2.1	20.0	20.0	0.017	L10.
37	15-SEP-87	7.2	14.6	6.6	6.3	8.80	317	1.9	20.0	20.0	0.017	
38	15-SEP-87	7.5	15.6	7.3	6.7	8.50	313	1.9	21.0	21.0	0.015	
39	22-SEP-87											
40	22-SEP-87	7.1	6.8	8.5	6.6	8.00	312	2.8	21.0	30.0	0.020	L10.
41	22-SEP-87	6.8	19.5	8.8	8.7	8.00	313	4.9	20.0	28.0	0.024	L10.
42	22-SEP-87	7.2	33.0	8.7	7.3	8.00	311	2.7	21.0	28.0	0.018	L10.
43	22-SEP-87	6.9	33.0	8.5	8.5	8.40	312	2.8	21.0	30.0	0.017	L10.
44	28-MAR-88	6.9	7.0	7.0	6.9	1.62	109	3.0	7.0	7.1	0.036	
45	29-MAR-88	7.0	10.5	8.3	8.0	2.89	183	3.0	13.0	17.0	0.033	
46	31-MAR-88	7.1	8.6	7.5	7.3	2.49	163	3.4	11.0	10.0	0.035	
47	01-APR-88	7.1	9.4	8.3	8.0	2.42	146	3.0	9.0	9.9	0.029	
48	02-APR-88	7.1	9.6	8.3	8.0	2.46	145	3.2	9.0	8.5	0.030	
49	01-MAY-88	7.3	13.9	11.1	10.6	4.64	237	2.7	12.0	12.0	0.030	
50	01-MAY-88	7.1	14.0	10.9	10.2	4.78	237	2.4	12.0	12.0	0.022	
51	01-MAY-88	7.2	13.7	10.4	9.9	4.64	235	2.4	14.0	17.0	0.018	
52	02-MAY-88	7.2	13.5	10.3	9.5	4.90	233	2.0	14.0	12.0	0.024	

TABLE 8:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE 0

	SDATE	STIME	89825L DINOSEB	89820L METRIBUZIN	89985L CHLOROTHALONIL	02011L COLOR		20110L CALCIUM	10101L ALK.	02073L TURBID.	12107L Mg	19103L K	11103L Na
53	04-JUL-88	906	L.02			L5.		52.0	63.8	0.9	5.2	7.2	2.8
54	12-JUL-88	1756						50.0	202.0	200.0	6.1	67.2	21.2
55	12-JUL-88	2046						50.0	251.0	150.0	8.1	114.0	24.5
56	20-JUL-88	401	0.16				40	31.0	55.2	22.0	3.6	15.8	1.5
57	20-JUL-88	801	0.09				60	30.0	48.5	25.0	3.5	15.8	1.6
58	19-OCT-88	1036	0.42				25	37.0	31.1	11.0	5.5	3.3	2.7
59	19-OCT-88	1321	0.29				15	38.0	31.9	10.0	5.5	3.0	2.8
60	19-OCT-88	1651	0.17				10	40.0	34.8	7.2	5.4	2.4	2.9
61	19-OCT-88	2116	0.33				5	40.0	37.1	2.6	5.3	2.2	3.0
62	20-OCT-88	201	0.16			L5.		41.0	39.0	2.3	5.3	2.2	3.1
63	20-OCT-88	501	0.05			L5.		41.0	40.5	1.2	5.2	2.1	3.1
64	11-APR-89	1551	0.08					7.1	19.7	29.0	1.7	5.3	0.5
65	11-APR-89	1556	0.06					7.2	19.8	30.0	1.7	5.1	0.5
66	12-APR-89	646	0.06				55	7.6	17.7	9.0	1.6	4.8	0.5
67	12-APR-89	647	0.03				55	7.6	17.8	9.2	1.6	3.7	0.5

	SDATE	10301L pH	17209L Cl / IC	16304L SO4 /MTB	16309L SO4 /IC	14102L Si	02041L SP.COND.	06107L DOC	07110L NO3 + NO2	07601L TOT. N	15413L PO4	10401L RESIDUE
53	04-JUL-88	8.1	9.7	7.9	8.1	7.60	353	2.0		20.0	0.038	
54	12-JUL-88	6.9	14.4	35.7	24.9	11.10	609	41.0	11.0	11.0		
55	12-JUL-88	7.1	18.1	39.1	24.7	12.20	726	80.0	15.2	16.0		
56	20-JUL-88	6.7	7.4	11.9	10.1	7.50	246	7.2	12.0	12.0		
57	20-JUL-88	6.6	7.6	13.7	10.2	7.20	245	7.6	11.0	11.0		
58	19-OCT-88	7.0	19.6	13.4	13.2	6.70	278	2.9	13.0	16.0	0.050	
59	19-OCT-88	7.1	20.0	12.3	12.1	6.70	284	2.4	14.0	16.0	0.037	
60	19-OCT-88	7.1	21.0	11.1	12.9	7.00	291	2.0	14.0	20.0	0.027	
61	19-OCT-88	7.2	20.0	10.6	11.7	7.30	293	1.6	15.0	16.5	0.020	
62	20-OCT-88	7.1	18.6	10.0	10.2	7.30	295	1.6	15.0	19.0	0.019	
63	20-OCT-88	7.1	18.7	9.6	10.5	7.30	297	1.3	15.0	18.0	0.015	
64	11-APR-89	7.1	3.4	3.6	3.1	1.10	70	6.5	1.2	1.2	0.120	
65	11-APR-89	7.1	3.3	3.6	3.1	1.20	70	5.9	1.0	1.0	0.100	
66	12-APR-89	6.9	3.7	4.5	4.3	1.50	70	5.1	1.5	1.2	0.050	
67	12-APR-89	7.0	3.8	4.5	4.3	1.50	71	5.2	1.5	1.2	0.050	

TABLE 9:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE P

	SDATE	STIME	89825L DINOSEB	02011L COLOR		20110L CALCIUM	10101L ALK.	02073L TURBID.	12107L Mg	19103L K	11103L Na	10301L pH	17209L Cl / IC	16304L SO4 /MTB
1	07-APR-87	1645	1.10											
2	08-APR-87	946	0.83	L5.		65.0	2.6	2.5	18.0	3.4	2.5	6.5	5.9	82.0
3	22-SEP-87	900	0.23	L5.		66.1	7.0	1.0	18.2	7.6	3.9	6.1	63.0	77.2
4	22-SEP-87	1000	0.20	L5.		66.3	7.7	1.2	17.7	8.4	4.0	6.3	61.0	77.2
5	22-SEP-87	1340	0.22	L5.		65.4	7.6	1.3	18.0	8.2	3.8	6.4	61.0	77.2
6	22-SEP-87	1600	0.14	L5.		65.7	7.5	1.4	18.2	7.8	3.9	6.2	81.0	77.2
7	28-MAR-88	956	0.09		10	33.0	9.5	4.1	8.0	6.1	1.7	6.7	12.7	82.7
8	29-MAR-88	1756	0.11		5	38.0	10.3	2.1	9.0	6.0	1.8	7.0	15.4	92.3
9	31-MAR-88	1406	0.12		5	37.0	12.0	2.7	8.7	6.0	1.8	6.7	14.4	91.8
10	01-APR-88	916	0.07		5	37.0	12.0	2.6	8.6	3.6	1.9	7.1	14.2	88.3
11	02-APR-88	821	0.09		5	36.0	12.6	2.6	8.4	3.6	1.8	7.1	12.9	86.7
12	03-APR-88	951	0.12		5	36.0	13.9	2.7	8.2	3.5	1.8	7.1	13.2	84.3
13	01-MAY-88	1305	L.02	L5.		49.0	13.9	0.8	12.0	4.0	2.8	6.9	24.9	95.7
14	01-MAY-88	1705	L.02	L5.		49.0	13.7	0.8	12.0	4.0	2.8	6.9	24.9	97.8
15	01-MAY-88	2105	L.02	L5.		49.0	13.4	0.7	12.0	3.9	2.8	6.9	25.8	96.9
16	02-MAY-88	50	L.02	L5.		47.0	13.2	0.7	12.0	3.9	2.8	6.8	24.8	98.4
17	04-JUL-88	726	1.30	L5.		39.0	26.7	2.0	8.7	6.8	2.4	7.3	12.6	71.0
18	04-JUL-88	1151	0.60	L5.		39.0	27.6	1.9	8.9	6.8	2.4	7.2	13.1	68.2
19	04-JUL-88	1546	0.59	L5.		38.0	25.9	2.0	8.8	6.6	2.4	7.3	13.0	69.6
20	04-JUL-88	1956	0.45	L5.		38.0	26.0	2.1	8.7	6.4	2.4	7.2	13.2	69.2
21	04-JUL-88	2356	0.68	L5.		38.0	28.1	1.7	8.6	6.1	2.6	7.3	13.9	69.6
22	05-JUL-88	356	0.06	L5.		38.0	23.5	1.6	9.1	7.0	2.6	7.3	14.4	69.6
23	05-SEP-88	1135	1.15											
24	05-SEP-88	1530	3.10											
25	15-OCT-88	721	0.07	L5.		43.0	6.7	0.4	11.0	5.5	3.2	6.7	21.0	87.0
26	16-OCT-88	731	0.02	L5.		41.0	5.4	0.2	10.0	5.3	2.9	6.6	22.0	92.0
27	19-OCT-88	841	1.20	L5.		44.0	4.0	0.7	11.0	5.5	3.0	6.5	24.0	87.0
28	19-OCT-88	1206	0.72	L5.		44.0	6.1	0.7	11.0	5.5	3.0	6.6	24.0	87.0
29	19-OCT-88	1551	0.35	L5.		45.0	8.4	0.7	11.0	5.2	3.0	6.6	22.0	88.0
30	19-OCT-88	2001	0.42	L5.		47.0	8.1	0.5	11.0	5.2	2.9	6.7	23.0	87.0
31	19-OCT-88	2351	0.23	L5.		46.0	7.5	0.2	11.0	5.2	2.9	6.7	23.0	90.0
32	20-OCT-88	351	0.20	L5.		46.0	7.5	0.4	11.0	5.2	2.9	6.6	23.0	90.0
33	20-OCT-88	806	0.34	L5.		46.0	7.5	0.3	11.0	5.2	2.9	6.6	22.5	90.0
34	20-OCT-88	1206	0.48	L5.		46.0	7.4	0.3	11.0	5.4	2.9	6.6	22.4	90.0
35	20-OCT-88	1546	0.33	L5.		46.0	8.0	0.3	11.0	7.1	2.9	6.7	23.0	90.0
36	20-OCT-88	2001	0.23	L5.		45.0	6.8	0.2	11.0	5.2	3.0	6.7	23.0	90.0
37	11-APR-89	1451	5.10		20	21.0	13.4	5.2	4.6	4.3	1.0	7.0	5.3	49.7
38	11-APR-89	1453	5.00		20	21.0	13.2	5.4	4.6	4.1	1.0	6.9	5.3	49.7
39	11-APR-89	1456	4.50		20	21.0	13.3	6.0	4.6	6.0	1.0	7.0	5.3	49.7
40	12-APR-89	736	1.10		5	26.0	7.6	1.7	5.7	4.3	1.2	6.8	6.8	65.5
41	12-APR-89	738	1.20		5	26.0	7.5	1.9	5.7	3.9	1.2	6.9	6.8	65.5
42	12-APR-89	740	1.10		5	26.0	7.5	1.9	5.7	3.5	1.2	6.9	6.8	65.5

TABLE 9:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE P

	SDATE	16309L SO4 /IC	14102L Si	02041L SP.COND.	06107L DOC	07110L NO3 + NO2	07601L TOT. N	15413L PO4	10401L RESIDUE
1	07-APR-87								
2	08-APR-87	76.0	5.44	576	2.5		35.0	0.011	
3	22-SEP-87	80.0	9.00	580	3.0	26.0	39.0	0.014	L10.
4	22-SEP-87	80.0	9.00	583	3.2	26.0	39.0	0.014	L10.
5	22-SEP-87	80.0	9.00	582	3.1	26.0	37.0	0.013	L10.
6	22-SEP-87	80.0	9.30	580	3.2	26.0	35.0	0.035	L10.
7	28-MAR-88	81.0	4.19	277	5.5	3.4	3.4	0.033	
8	29-MAR-88	92.0	4.88	310	4.6	4.1	4.7	0.017	
9	31-MAR-88	92.0	4.84	299	4.6	3.8	4.2	0.021	
10	01-APR-88	92.0	4.80	296	4.6	3.9	4.4	0.018	
11	02-APR-88	85.0	4.71	290	4.4	3.7	4.0	0.021	
12	03-APR-88	85.0	4.75	286	4.4	3.7	4.1	0.021	
13	01-MAY-88	95.0	7.90	401	2.4	8.0	8.3	0.010	
14	01-MAY-88	95.0	8.00	399	2.7	8.0	7.6	0.004	
15	01-MAY-88	95.0	8.00	396	2.5	8.0	8.1	0.004	
16	02-MAY-88	94.0	7.90	395	2.5	8.0	8.3	0.005	
17	04-JUL-88	66.0	10.30	307	4.2		4.5	0.023	
18	04-JUL-88	68.0	10.40	312	4.0		4.5	0.046	
19	04-JUL-88	68.0	10.60	311	3.8		4.5	0.015	
20	04-JUL-88	68.0	10.70	309	3.5		4.5	0.013	
21	04-JUL-88	69.0	10.70	312	3.7	6.9	7.2	0.017	
22	05-JUL-88	69.0	10.70	310	3.1	6.9	7.2	0.013	
23	05-SEP-88								
24	05-SEP-88								
25	15-OCT-88	84.0	8.50	352	2.1	8.0	8.0	0.002	
26	16-OCT-88	88.5	8.30	349	2.0	8.3	8.5	0.002	
27	19-OCT-88	88.0	8.10	387	2.1	13.0	15.0	0.005	
28	19-OCT-88	88.0	8.50	378	2.1	12.0	15.0	0.004	
29	19-OCT-88	90.0	8.30	379	2.0	11.0	14.0	0.004	
30	19-OCT-88	85.0	8.40	382	2.3	11.5	12.0	0.005	
31	19-OCT-88	87.0	7.00	383	2.5	11.0	15.0	0.005	
32	20-OCT-88	90.0	8.40	380	2.5	10.5	13.0	0.004	
33	20-OCT-88	90.0	8.30	379	2.5	10.2	15.0	0.004	
34	20-OCT-88	90.0	8.30	378	2.1	10.5	14.0	0.003	
35	20-OCT-88	91.0	8.30	378	2.3	10.5	15.0	0.002	
36	20-OCT-88	89.0	7.10	373	2.0	10.5	12.0	0.003	
37	11-APR-89	47.0	3.70	177	3.3	3.0	3.0	0.080	
38	11-APR-89	47.0	3.60	178	2.6	3.1	3.1	0.090	
39	11-APR-89	47.0	3.60	178	3.3	3.4	3.0	0.080	
40	12-APR-89	66.0	4.30	211	2.2	3.2	3.5	0.015	
41	12-APR-89	65.0	4.30	212	2.3	3.6	4.1	0.016	
42	12-APR-89	64.0	4.40	216	2.3	3.5	3.5	0.011	

TABLE 10:

PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE R

	SDATE	STIME	89825L DINOSEB	89410L MCPA	89820L METRIBUZIN	02011L COLOR		20110L CALCIUM	10101L ALK.	02073L TURBID.	12107L Mg	19103L K	11103L Na	10301L pH
1	07-APR-87	1445	0.11											
2	08-APR-87	1101	0.14			L5.		68.0	5.7	0.7	12.0	1.8	1.8	6.6
3	28-JUN-87	1335	L.02		L.01		5	72.0	14.2	2.6	12.0	6.0	2.8	6.8
4	28-JUN-87	1445	L.02		L.01	L5.		73.0	13.9	0.5	12.0	3.8	2.8	7.0
5	28-JUN-87	2030	L.02		L.01	L5.		75.0	13.1	1.1	12.0	4.3	2.8	7.2
6	28-JUN-87	2335	L.02		L.01	L5.		74.0	12.9	0.5	12.0	3.9	2.8	6.9
7	14-SEP-87	1700	44.00											
8	22-SEP-87	400	1.40											
9	22-SEP-87	900	2.00			L5.		77.3	10.4	0.3	12.4	4.3	3.0	6.6
10	22-SEP-87	920	1.74			L5.		79.4	10.4	0.4	12.2	4.1	2.9	7.1
11	22-SEP-87	1305	1.71			L5.		77.3	10.6	0.3	12.4	4.1	3.0	7.0
12	22-SEP-87	1600				L5.		78.1	10.6	0.3	12.4	4.5	2.9	6.5
13	23-SEP-87	1201	0.58											
14	23-SEP-87	1205	0.59											
15	23-SEP-87	1210	0.81											
16	23-SEP-87	1220	1.20											
17	04-OCT-87	930	0.88			L5.		81.9	15.6	0.4	13.0	4.6	2.7	7.2
18	04-OCT-87	1330	1.00			L5.		83.1	14.2	1.6	13.3	6.1	2.7	6.8
19	04-OCT-87	1630	0.91			L5.		81.9	12.6	1.2	13.4	4.5	2.7	6.7
20	04-OCT-87	2015	0.47			L5.		82.5	11.4	1.2	13.7	4.3	2.7	6.5
21	04-OCT-87	2400	0.43			L5.		82.1	10.5	0.8	14.1	4.5	2.8	7.0
22	05-OCT-87	405	0.43			L5.		83.8	8.5	1.0	14.6	4.6	2.8	6.2
23	05-OCT-87	930	0.34			L5.		84.4	8.0	0.5	17.7	4.3	2.8	6.4
24	05-OCT-87	1330	0.35			L5.		83.4	7.9	0.4	14.7	5.1	2.8	6.3
25	05-OCT-87	1631	0.32			L5.		82.6	8.3	0.5	14.8	4.3	2.8	6.1
26	05-OCT-87	2001	0.19			L5.		83.0	8.1	0.5	14.6	4.2	2.8	6.2
27	05-OCT-87	2356	0.19			L5.		82.3	8.3	0.4	14.7	4.9	2.8	6.4
28	06-OCT-87	356	0.24			L5.		80.7	8.5	0.3	14.6	4.3	2.8	6.8
29	06-OCT-87	801	0.20			L5.		81.2	8.6	0.4	13.4	3.8	2.8	6.9
30	06-OCT-87	1301	0.17			L5.		82.0	9.1	0.3	13.5	4.5	2.9	6.2
31	06-OCT-87	1601	0.21			L5.		80.3	9.4	0.3	13.4	3.9	2.9	6.3
32	06-OCT-87	2001	0.20			L5.		81.2	9.5	0.3	13.3	3.9	2.9	6.4
33	29-MAR-88	1504	0.57			L5.		49.0	5.9	1.5	8.5	2.8	1.1	6.7
34	31-MAR-88	1101	0.44			L5.		48.0	5.8	0.8	8.5	2.9	1.1	6.7
35	01-APR-88	1016	0.76			L5.		45.0	5.5	1.0	7.8	2.8	1.1	6.9
36	02-APR-88	926	0.86				5	44.0	5.7	5.4	7.7	2.8	1.1	6.9
37	03-APR-88	1041	0.96			L5.		44.0	6.0	1.9	7.7	2.8	1.1	6.8
38	04-APR-88	1136	L.02				5	39.0	4.8	3.0	6.7	2.8	1.1	6.8
39	01-MAY-88	1405	L.02		L.003	L5.		61.0	13.4	0.1	9.7	2.7	2.3	7.2
40	01-MAY-88	1740	L.02		L.003	L5.		61.0	12.9	0.2	9.6	2.7	2.3	7.2
41	01-MAY-88	2135	0.04		L.003	L5.		61.0	12.4	0.2	9.8	2.7	2.3	7.2
42	02-MAY-88	120	0.03		L.003	L5.		62.0	11.3	0.1	9.8	2.8	2.5	6.7
43	04-MAY-88	810		L.001		L5.		39.5	13.1	0.6	6.4	3.1	1.7	7.0
44	04-JUL-88	1226		L.001		L5.		42.0	14.6	0.4	6.7	2.9	1.9	6.3
45	04-JUL-88	1621		L.001		L5.		45.0	15.0	0.4	7.2	3.0	2.0	7.1
46	04-JUL-88	1941		L.001		L5.		45.0	15.8	0.3	7.1	2.8	2.1	7.1
47	05-JUL-88	421		L.001		L5.		48.0	15.6	0.3	7.3	2.5	2.2	7.2
48	05-JUL-88	1201		L.001		L5.		46.0	15.6	0.3	7.2	2.5	2.3	7.1
49	15-OCT-88	801	L.02			L5.		68.0	21.8	0.4	9.6	4.3	3.5	6.8
50	16-OCT-88	821	L.02			L5.		68.0	23.2	0.2	9.3	4.3	3.5	7.1
51	19-OCT-88	916	L.02			L5.		64.0	32.8	1.1	8.3	4.0	3.0	7.2
52	19-OCT-88	1241	L.02			L5.		64.0	30.0	0.3	8.4	3.9	3.0	7.2

TABLE 10:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE R

	SDATE	17209L Cl / IC	16304L SO4 /MTB	16309L SO4 /IC	14102L Si	02041L SP.COND.	06107L DOC	07110L NO3 + NO2	07601L TOT. N	15413L PO4	10401L RESIDUE
1	07-APR-87										
2	08-APR-87	32.5	8.6	7.1	4.32	542	1.4	46.0	46.0	0.006	
3	28-JUN-87	31.0	5.6	4.9	6.18	568		53.0	54.0		
4	28-JUN-87	31.0	5.6	4.6	6.14	563	1.6	53.0	59.0		
5	28-JUN-87	32.0	5.7	5.1	6.21	584	1.5	60.0	57.0		
6	28-JUN-87	32.0	5.2	4.6	6.27	579	1.2	53.0	86.0		
7	14-SEP-87										
8	22-SEP-87										
9	22-SEP-87	33.0	7.9	8.1	7.00	598	3.2	58.0	89.0	0.003	L10.
10	22-SEP-87	33.0	7.7	7.8	6.70	590	1.3	57.0	86.0	0.002	L10.
11	22-SEP-87	33.0	7.7	8.2	7.00	591	1.6	57.0	91.0	0.002	L10.
12	22-SEP-87	33.0	7.9	8.2	6.90	594	1.4	57.0	91.0	0.002	L10.
13	23-SEP-87										
14	23-SEP-87										
15	23-SEP-87										
16	23-SEP-87										
17	04-OCT-87	46.0	9.9	12.7	7.40	613	1.1	60.0	78.0		
18	04-OCT-87	46.0	9.1	11.8	7.30	622	1.4	60.0	82.0		
19	04-OCT-87	46.0	8.7	10.8	7.10	622	1.1	60.0	88.0		
20	04-OCT-87	41.0	8.3	9.4	7.10	628	1.2	60.0	92.0		
21	04-OCT-87	41.0	8.5	9.8	7.10	629	1.3	60.0	86.0		
22	05-OCT-87	45.0	7.7	8.8	6.80	642	1.2	60.0	87.0		
23	05-OCT-87	44.0	7.9	9.1	7.10	643	0.9	60.0	94.0		
24	05-OCT-87	43.0	7.9	8.8	7.10	641	0.9	60.0	89.0		
25	05-OCT-87	47.0	8.1	9.0	7.10	635	1.0	62.0	89.0		
26	05-OCT-87	46.0	8.1	8.6	7.10	631	1.0	60.0	87.0		
27	05-OCT-87	45.0	7.9	8.6	7.10	629	0.9	62.0	90.0		
28	06-OCT-87	46.0	8.1	8.6	7.40	631	0.9	62.0	98.0		
29	06-OCT-87	44.0	7.7	8.6	7.40	632	1.0	62.0	86.0		
30	06-OCT-87	45.0	7.8	8.8	7.40	631	L.5	64.0	90.0		
31	06-OCT-87	44.0	7.7	8.6	7.40	631	L.5	64.0	89.0		
32	06-OCT-87	45.0	7.7	8.8	7.40	628	L.5	64.0	89.0		
33	29-MAR-88	25.0	7.9	7.6	3.90	393	1.3	34.0	36.0	0.005	
34	31-MAR-88	25.4	7.8	7.4	3.91	396	1.3	34.0	34.0	0.004	
35	01-APR-88	23.2	7.7	7.3	3.66	364	1.5	30.0	30.0	0.006	
36	02-APR-88	22.0	7.9	7.4	3.74	357	1.5	30.0	31.0	0.009	
37	03-APR-88	22.0	8.0	7.5	3.71	356	1.7	30.0	31.0	0.008	
38	04-APR-88	20.2	7.8	7.3	3.39	314	2.2	23.0	26.5	0.013	
39	01-MAY-88	29.1	8.0	6.8	6.60	472	1.2	43.0	39.0	L.001	
40	01-MAY-88	29.2	8.2	7.0	6.40	472	1.0	42.0	45.0	L.001	
41	01-MAY-88	29.0	8.3	6.9	6.30	472	0.8	42.0	67.0	L.001	
42	02-MAY-88	28.2	8.5	7.1	6.30	473	0.8	45.0	69.0	L.001	
43	04-MAY-88	15.0	6.9	6.7	7.90	303	1.5	22.0	23.0	0.006	
44	04-JUL-88	16.4	6.7	6.4	8.10	324	1.3	30.0	26.0	0.003	
45	04-JUL-88	17.4	6.7	6.4	8.40	340	1.1	26.0	28.0	0.002	
46	04-JUL-88	18.1	6.6	6.3	8.60	343	1.1	31.0	28.0	0.002	
47	05-JUL-88	18.7	6.5	6.2		357	1.1	28.0	28.0	0.005	
48	05-JUL-88	18.3	6.5	6.2	8.70	353	1.1	32.0	36.0	0.008	
49	15-OCT-88	34.0	11.3	12.8	7.30	500	0.6	44.0	32.0	0.001	
50	16-OCT-88	33.0	10.8	12.5	7.00	499	0.9	41.0	42.0	0.015	
51	19-OCT-88	29.0	13.0	15.1	7.00	456	1.6	33.0	34.0	0.004	
52	19-OCT-88	29.0	12.0	13.6	7.00	461	1.3	34.0	34.0	0.002	

TABLE 10:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE R

SDATE	STIME	89825L DINOSEB	89410L MCPA	89820L METRIBUZIN	02011L COLOR	20110L CALCIUM	10101L ALK.	02073L TURBID.	12107L Mg	19103L K	11103L Na	10301L pH
53 19-OCT-88	1621	L.02			L5.	66.0	28.8	0.3	8.6	3.5	3.0	7.1
54 19-OCT-88	2031	L.02			L5.	65.0	25.7	0.2	8.8	3.5	2.6	6.9
55 20-OCT-88	131	L.02			L5.	66.0	25.9	0.3	8.9	3.5	2.6	7.0
56 20-OCT-88	431	L.02			L5.	66.0	24.8	0.2	9.0	3.5	2.6	7.0
57 20-OCT-88	836	L.02			L5.	65.0	23.7	0.2	9.0	3.5	2.6	7.0
58 20-OCT-88	1241	L.02			L5.	66.0	23.9	0.1	9.0	3.5	2.6	6.9
59 20-OCT-88	1611	L.02			L5.	66.0	23.4	0.1	9.1	3.5	3.2	7.2
60 20-OCT-88	2031	L.02			L5.	66.0	22.2	0.1	9.1	3.3	2.4	7.0
61 11-APR-89	1321	L.02	L.001		L5.	17.0	9.7	0.9	2.8	2.0	1.0	6.9
62 11-APR-89	1326	L.02	L.001		L5.	17.0	9.9	0.9	2.8	2.0	1.0	6.9
63 12-APR-89	816	L.02	L.001		L5.	18.0	9.7	0.9	2.7	1.8	1.0	7.1
64 12-APR-89	821	L.02	L.001		L5.	18.0	10.1	0.9	2.7	1.8	1.0	7.1

SDATE	17209L Cl / IC	16304L SO4 /MTB	16309L SO4 /IC	14102L Si	02041L SP.COND.	06107L DOC	07110L NO3 + NO2	07601L TOT. N	15413L PO4	10401L RESIDUE
53 19-OCT-88	29.0	11.4	13.0	7.30	464	1.2	35.0	35.0	0.002	
54 19-OCT-88	31.0	12.1	12.5	6.80	459	1.2	36.0	36.0	0.002	
55 20-OCT-88	33.0	12.1	12.5	6.80	472	1.3	36.0	36.0	0.002	
56 20-OCT-88	31.0	12.1	11.0	7.10	474	1.3	35.0	35.0	0.001	
57 20-OCT-88	33.0	11.8	11.4	7.40	474	0.8	36.0	36.0	0.002	
58 20-OCT-88	33.0	11.9	12.0	7.10	472	0.8	38.0	38.0	0.001	
59 20-OCT-88	37.0	11.8	11.0	7.10	478	0.8	36.0	36.0	0.002	
60 20-OCT-88	33.0	11.2	11.0	6.80	452	1.0	38.0	38.0	0.002	
61 11-APR-89	8.0	11.0	10.8	4.10	142	1.4	7.9	7.9	0.013	
62 11-APR-89	8.0	11.0	10.7	4.10	143	1.6	7.9	7.7	0.013	
63 12-APR-89	7.8	10.7	10.7	4.20	142	1.5	7.9	7.9	0.010	
64 12-APR-89	7.8	11.0	10.9	4.20	142	1.5	7.9	8.1	0.009	

TABLE 11:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE S

	SDATE	STIME	89825L DINOSEB	02011L COLOR		20110L CALCIUM	10101L ALK.	02073L TURBID.	12107L Mg	19103L K	11103L Na	10301L pH	17209L Cl / IC	16304L SO4 /MTB
1	07-APR-87	1515	0.17											
2	08-APR-87	1031	0.20	L5.		75.0	23.6	1.4	13.0	1.70	2.3	7.1	30.0	110.0
3	17-JUN-87	1000	L.02	L5.		74.0	118.9	0.7	5.4	0.52	2.6	8.0	16.4	39.1
4	17-JUN-87	1330	L.02	L5.		74.0	120.2	0.7	5.3	0.71	2.6	7.9	15.8	38.4
5	17-JUN-87	1600	L.02	L5.		74.0	122.2	0.2	5.3	0.69	2.6	8.0	15.6	39.2
6	17-JUN-87	2000	L.02	L5.		76.0	121.7	0.2	5.3	0.67	2.6	8.0	15.9	39.2
7	28-JUN-87	320		L5.		64.0	64.4	0.5	6.7	3.00	2.6	7.1	14.3	40.3
8	28-JUN-87	1420	0.14	L5.		60.0	54.4	0.6	6.4	4.90	2.6	7.5	12.6	31.0
9	28-JUN-87	1650	0.57		5	58.0	42.3	7.4	6.9	5.50	2.5	7.0	12.8	33.4
10	28-JUN-87	2100	0.14	L5.		61.0	53.2	1.4	6.8	3.90	2.6	7.5	13.4	34.8
11	28-JUN-87	2102	0.18	L5.		60.0	53.4	0.8	6.8	5.30	2.6	7.7	13.3	34.3
12	28-JUN-87	2104	0.10	L5.		61.0	53.2	1.4	6.8	3.80	2.6	7.3	13.4	34.0
13	29-JUN-87	320	0.08											
14	29-JUN-87	545	0.06	L5.		65.0	67.5	0.8	6.7	2.90	2.7	7.1	14.5	41.2
15	29-JUN-87	1220	0.12	L5.		62.0	58.9	0.8	6.7	3.60	2.6	7.0	13.9	37.8
16	03-AUG-87	755			10	58.0	67.0	7.2	5.3	3.00	2.5	7.4	12.2	29.4
17	03-AUG-87	2400		L5.			75.7	2.7		2.70	2.5	8.2	11.6	36.0
18	04-AUG-87	356		L5.		70.0	95.6	0.4	5.7	1.90	2.9	7.7	14.0	29.5
19	04-AUG-87	400		L5.		63.3	84.1	0.7	9.1	2.30	2.6	7.5	12.6	29.5
20	04-AUG-87	756		L5.		69.0	99.0	0.4	5.5	1.80	2.8	7.5	14.3	29.5
21	04-AUG-87	800		L5.			87.6	0.6		2.10	2.7	7.8	13.9	29.4
22	04-AUG-87	1156		L5.		70.0	92.2	0.6	5.7	2.00	2.8	7.7	15.9	30.0
23	04-AUG-87	1202		L5.		71.0	101.0	0.3	5.9	1.70	2.9	8.0	14.4	31.5
24	05-AUG-87	401		L5.		70.0	102.2	0.3	5.6	1.70	2.9	8.1	14.4	31.5
25	05-AUG-87	402			5	74.0	105.9	8.1	5.9	1.50	2.9	7.7	15.0	32.0
26	05-AUG-87	801		L5.		71.0	102.6	0.3	5.8	1.60	2.9	8.0	14.8	32.0
27	05-AUG-87	1156		L5.		73.0	104.6	0.3	5.8	1.60	2.9	7.7	14.9	32.0
28	14-SEP-87	1730	0.44											
29	14-SEP-87	1735	0.42											
30	14-SEP-87	1740	0.24											
31	23-SEP-87	1745	0.05											
32	23-SEP-87	1750	L.02											
33	23-SEP-87	1751	L.02											
34	30-OCT-87	1700	L.02											
35	30-OCT-87	1702	L.02											
36	30-OCT-87	1704	L.02											
37	04-NOV-87	1130	L.02											
38	04-NOV-87	1132	L.02											
39	04-NOV-87	1134	L.02											
40	29-MAR-88	1611	0.07		5	53.0	16.7	3.6	8.9	2.80	1.1	7.0	23.0	71.9
41	31-MAR-88	1156	0.04		10	38.0	16.7	6.0	5.7	2.40	1.7	7.0	15.3	49.6
42	01-APR-88	1046	0.02		10	34.0	14.8	7.0	5.3	2.20	1.5	7.2	13.7	45.1
43	02-APR-88	1011	0.02		15	34.0	14.3	7.4	5.3	2.20	1.5	7.0	13.7	47.1
44	03-APR-88	1111	0.03		15	39.0	15.9	7.4	6.3	2.30	1.6	7.1	16.0	54.9
45	04-APR-88	1231	0.06		20	33.0	8.2	8.3	5.5	2.20	1.3	6.8	14.4	48.2
46	03-MAY-88	1531	L.02	L5.		73.0	67.9	0.6	9.1	1.80	2.8	8.1	24.9	62.0
47	07-JUL-88	1431	L.02	L5.		72.0	82.0	0.9	5.4	1.00	2.9	8.1	14.3	36.0
48	08-SEP-88	1446	0.20	L5.		88.0	70.2	0.2	12.0	3.30	3.6	7.2	32.0	95.8
49	11-APR-89	1351	L.02		5	41.0	41.3	4.5	4.8	1.90	1.6	7.4	9.9	59.8
50	11-APR-89	1356	L.02		5	41.0	41.5	2.8	4.8	1.90	1.7	7.3	9.9	59.8
51	12-APR-89	846	L.02	L5.		41.0	39.4	1.3	5.0	1.90	1.7	7.0	9.8	60.4
52	12-APR-89	851	L.02	L5.		41.0	39.9	1.4	4.9	1.90	1.7	7.0	9.8	61.3

TABLE 11:
PESTICIDE (UG/L) AND MAJOR ION/NUTRIENT (MG/L)
DATA FOR SITE S

	SDATE	16309L SO4 /IC	14102L Si	02041L SP.COND.	06107L DOC	07110L NO3 + NO2	07601L TOT. N	15413L PO4	10401L RESIDUE
1	07-APR-87								
2	08-APR-87	103.0	5.16	541	2.0	20.0	20.0	0.009	
3	17-JUN-87	36.8	9.37	432	0.7	11.0	15.0	0.011	
4	17-JUN-87	35.9	9.42	434	L.5	12.0	10.0	0.008	
5	17-JUN-87	35.0	9.33	434	L.5	12.0	11.0	0.003	
6	17-JUN-87	36.0	9.33	437	L.5	12.0	11.0	0.003	
7	28-JUN-87	35.9	7.80	414	1.3	22.0	23.0		
8	28-JUN-87	28.9	6.63	406	1.8	24.0	26.0		
9	28-JUN-87	31.2	6.23	411	2.4	27.0	28.0		
10	28-JUN-87	33.3	6.76	418	1.8	24.0	27.0		
11	28-JUN-87	33.1	3.22	417	1.9	24.0	25.0		
12	28-JUN-87	33.3	7.20	412	1.9	25.0	25.0		
13	29-JUN-87								
14	29-JUN-87	36.7	8.10	418	1.3	21.0	20.0		
15	29-JUN-87	34.9	7.60	417	1.5	23.0	24.0		
16	03-AUG-87	28.7	8.80	377	2.9	18.0	18.0		
17	03-AUG-87	29.9	9.20	392	2.2	19.0	20.0		
18	04-AUG-87	30.0	10.50	430	1.2	17.0	17.0	0.002	
19	04-AUG-87	30.0	9.60	410	1.4	19.0	22.0	0.007	
20	04-AUG-87	31.0	10.50	432	0.9	16.0	16.0	0.003	
21	04-AUG-87	28.5	9.60	416	1.2	18.0	18.0		
22	04-AUG-87	30.8	10.10	426	1.2	17.0	17.0	0.007	
23	04-AUG-87	31.0	10.50	433	1.0	16.0	16.0	0.002	
24	05-AUG-87	32.0	10.90	435	0.8	16.0	16.0	0.002	
25	05-AUG-87	32.0	10.50	447	0.8	16.5	24.0	0.008	
26	05-AUG-87	32.0	10.90	436	0.8	16.0	16.0	0.002	
27	05-AUG-87	33.0	11.10	442	0.8	18.5	32.0	0.002	
28	14-SEP-87								
29	14-SEP-87								
30	14-SEP-87								
31	23-SEP-87								
32	23-SEP-87								
33	23-SEP-87								
34	30-OCT-87								
35	30-OCT-87								
36	30-OCT-87								
37	04-NOV-87								
38	04-NOV-87								
39	04-NOV-87								
40	29-MAR-88	70.0	4.09	390	2.0	16.0	16.0	0.009	
41	31-MAR-88	47.0	3.35	281	2.4	11.0	12.0	0.023	
42	01-APR-88	43.0	3.10	259	2.5	9.0	11.0	0.027	
43	02-APR-88	45.0	2.86	256	2.5	10.0	11.0	0.026	
44	03-APR-88	55.0	3.19	298	2.5	12.0	13.0	0.019	
45	04-APR-88	44.0	2.33	251	2.7	10.0	8.5	0.032	
46	03-MAY-88	61.0	8.10	482	1.2	20.0	29.0	0.002	L10.
47	07-JUL-88	34.5	12.30	435	0.9	10.0	10.0	0.003	
48	08-SEP-88	95.6	10.30	591	1.3	22.0	23.0	L.001	
49	11-APR-89	60.0	5.20	272	1.7	3.9	4.1	0.014	
50	11-APR-89	60.0	5.10	274	1.8	3.8	3.8	0.014	
51	12-APR-89	62.0	5.10	270	1.7	3.7	3.8	0.011	
52	12-APR-89	62.0	5.00	271	1.7	3.8	3.8	0.010	

APPENDIX I

1987 CHEMICAL APPLICATION RECORDS

SITE B

CROP: Timothy Clover Hay

1 - 14 July: Good yield of hay harvested (round bales)

October 30: 2.5 T/ha lime applied (broadcast)

Planned 1988 Crop: Processing/table potatoes

SITE O

CROP: Processing/Table Potatoes (russets)

20 May: Crop planted with 1.1 T/ha 15-10-15 Fertilizer (banded), Seed was treated with captan

3 June: Applied 0.9 L/ha paraquat (Gramoxone 200 g/L) by ground sprayer

1 July: Applied 2.0 kg/ha mancozeb (Dithane M45) by airplane

8 July: Applied 2.0 kg/ha mancozeb by airplane

15 July: Applied 2.0 kg/ha mancozeb by airplane

22 July: Applied 2.0 kg/ha mancozeb by airplane

29 July: Applied 2.0 kg/ha mancozeb by airplane

5 August: Applied 2.0 kg/ha mancozeb by airplane

12 August: Applied 2.0 kg/ha mancozeb by airplane

19 August: Applied 2.0 kg/ha mancozeb by airplane

26 August: Applied 2.0 kg/ha mancozeb by airplane

2 September: Applied 2.0 kg/ha mancozeb by airplane

No insecticide was applied

No topkill was applied (frost)

5-11 October: Potatoes were harvested

N.B. Barley was seeded 20 May with 0.4T/ha 15-10-15 Fertilizer (banded) on 0.6 ha of the field near the main road and outlet. No other fertilizer or chemicals were applied. The barley was harvested during September.

Planned 1988 crop: Processing/table potatoes

SITE P

CROP: Fallow (sparse cover crop of winter rye planted fall, 1986)

23 July: Mowed rye crop left in field

11 August: Plowed 1/2 of field width

25 August: Plowed remainder of field

9 September: Seeded field to winter rye (160 kg/ha seed broadcast and harrowed-in)

No fertilizer or chemicals were applied

Planned 1988 Crop: Winter rye or potatoes

SITE R

CROP: Seed Potatoes (sebagos)

18-19 May: Crop planted with 1.0 T/ha 15-10-15 fertilizer (banded). Seed was treated with mancozeb and douglas fir bark (Tuber Seal)

8 June: Applied 2.5 L/ha paraquat (Gramoxone 200 g/L) by ground sprayer

10 July: Applied 2.0 kg/ha mancozeb (Dithane M45) by ground sprayer

22 July: Applied 2.0 kg/ha mancozeb (Dithane M45) by ground sprayer

28 July: Applied 5.6 L/ha seaweed extract (Sea Cure) by ground sprayer

5 August: Applied 2.0 kg/ha mancozeb (Dithane M45) by ground sprayer

18 August: Applied 2.0 kg/ha metalaxyl mancozeb (Ridomil MZ) by ground sprayer

4 September: Applied 1.5 kg/ha mancozeb (Dithane M45) and 11 L/ha dinoseb (Dytop 300 g/L) by ground sprayer

16 September: Applied 1.1 L/ha diquat (Reglone 200 g/L) by ground sprayer

29 September: Crop was harvested

No insecticide was used

Planned 1988 Crop: Seed or table potatoes

SITE S

CROP: Seed Potatoes (Atlantic)

18-19 May: Crop planted with 1.1 T/ha 10-10-10 fertilizer (banded) No seed treatment

8 June: Applied 4.5 L/ha dinoseb (Dytop 300 g/L) by ground sprayer

17 July: Applied 2.0 kg/ha mancozeb (Manzate 200) by ground sprayer

24 July: Applied 2.0 kg/ha mancozeb by ground sprayer

26 July: Applied 0.15 L/ha cypermethrin (Cymbush 250 EC) by ground sprayer on N. half of field

6 August: Applied 2.0 kg/ha mancozeb by ground sprayer

12 August: Applied 2.0 kg/ha mancozeb by ground sprayer

28 August: Applied 4.5 L/ha diquat (Reglone) by ground sprayer

15-30 September: Harvested crop

Planned 1988 Crop: Grain or grass

N.B. Approximately 1.0 ha at the E. (bottom) side of the field near the outlet was left fallow

NOTE: The above information is based on farmer reports during the growing season.

APPENDIX II

GROUNDWATER QUALITY PROJECT

1988 CHEMICAL APPLICATION RECORDS

SITE B

CROP:	Processing/table potatoes (russets)
May 11:	Broadcast 224 kg/ha muriated K
May 14:	Planted potatoes (except for a 35 m strip along the bottom of the field which was later seeded to annual rye grass). Banded 1350 kg/ha 15-15-15 (DAP, ammonium nitrite and ammonium sulfate) at planting.
May 30:	Applied 0.75 kg/ha metribuzin (Lexone DF). Applied 2.8 L/ha paraquat [Gramoxone(200 g/L)] on approximately the bottom third of monitored area.
July 4:	Applied 2 kg/ha mancozeb (Dithane M45). Applied 0.14 L/ha cypermethrin (Cymbush 250 EC). Applied 1.2 L/ha zinc.
July 11:	Applied 2 kg/ha mancozeb (Dithane M45). Applied 0.9 kg/ha sodium borate (Solubor).
July 18:	Applied 2 kg/ha mancozeb (Dithane M45). Applied 2.2 L/ha zinc. Applied 0.9 kg/ha sodium borate (Solubor).
July 25:	Applied 2 L/ha chlorothalonil (Bravo). Applied 0.5 kg/ha pirimicarb (PIrimor 50 WP).
August 2:	Applied 2.2 kg/ha metalaxyl mancozeb (Ridomil MZ).
August 17:	Applied 2 L/ha chlorothalonil (Bravo). Applied 0.5 kg/ha pirimicarb (Pirimor WP).
August 26:	Applied 2.2 kg/ha mancozeb (Dithane M45).
September 6:	Applied 2 L/ha chlorothalonil (Bravo).
September 10:	Applied 0.9 kg/ha mancozeb (Dithane M45). Applied 1.4 L/ha diquat (Reglone).
September 19:	Applied 0.9 kg/ha mancozeb (Dithane M45). Applied 1.4 L/ha diquat (Reglone).
October 1-4:	Harvested potato crop.

SITE O

CROP:	Field peas (for frozen processing)
June 4-8:	Seeded to field peas. Banded 340 kg/ha, 15-15-15 at seeding.
June 27:	Applied 5 L/ha MCPB (Tropotox).
August 13:	Began harvesting (several days were required to harvest the crop).
Late August:	Seeded to winter wheat for a cover crop.

SITE P

CROP:	Seed Potatoes (Norchips)
May 25:	Planted one-half of field with potatoes (far side of field). Applied 1350 kg/ha 10-12-12 (banded at planting). Near side of field left in fall rye (sparse cover).
June 7:	Applied 5.6 L/ha dinoseb (Dytop).
July 16:	Applied 2.2 kg/ha mancozeb (Manzate 200).
July 20:	Applied 2.2 kg/ha mancozeb (Manzate 200).
July 27:	Applied 2.2 kg/ha metalaxyl mancozeb (Ridomil MZ).
August 2:	Applied 2.2 kg/ha metalaxyl mancozeb (Ridomil MZ).
August 18:	Applied 5.6 L/ha dinoseb (Dytop).
August 24:	Applied 5.6 L/ha dinoseb (Dytop).
August 31:	Applied 5.6 L/ha dinoseb (Dytop).
September 11:	Harvested potato crop. Field left fallow over winter.

SITE R

CROP:	Barley (Leger) below first terrace. Oats (Nova) above first terrace.
May 5:	Seeded to barley (with tramline). Applied 112 kg/ha ammonium nitrate (banded) at seeding. Seeded to oats, underseeded with 70-15-15 grass seed above first terrace. 90 kg/ha ammonium nitrate banded at seeding.

June 4: Applied 1.2 L/ha MCPA. Applied 0.445 L/ha System 480E.

August 21: Harvested barley below first terrace (yield estimated to be 180 bu/ha).

September 6: Harvested oats (poor yield as was down in the clover).

SITE S

CROP: Barley

May 18: Seeded to barley. Banded 393 kg/ha 12-15-15 at seeding. Underseeded with 70-15-15 grass.

September 2-3: harvested approximately 185 bu/ha. Left in stubble and underseed for winter.